PHILOSOPHICAL TRANSACTIONS,

OF THE

ROYAL SOCIETY

OF

LONDON.

VOL. LXIX. For the Year 1779.

PART I.

LONDON,

PRINTED BY J. NICHOLS, SUCCESSOR TO MR. BOWYER;

FOR LOCKYER DAVIS, PRINTER TO THE ROYAL SOCIETY.

MDCCLXXIX.

PHILOSOPHICAL TRANSACTIONS

OF THE

ROYAL SOCIETY

OF

LONDON.

FOR THE YEAR MDCCLXXIV.

PART I.

ADVERTISEMENT.

THE Committee appointed by the *Royal Society* to direct the publication of the *Philoſophical Tranſactions*, take this opportunity to acquaint the Public, that it fully appears, as well from the council-books and journals of the Society, as from repeated declarations, which have been made in ſeveral former *Tranſactions*, that the printing of them was always, from time to time, the ſingle act of the reſpective Secretaries, till the Forty-ſeventh Volume: the Society, as a body, never intereſting themſelves any further in their publication, than by occaſionally recommending the revival of them to ſome of their Secretaries, when, from the particular circumſtances of their affairs, the *Tranſactions* had happened for any length of time to be intermitted. And this ſeems principally to have been done with a view to ſatisfy the Public, that their uſual meetings were then continued for the improvement of knowledge, and benefit of mankind, the great ends of their firſt inſtitution by the Royal Charters, and which they have ever ſince ſteadily purſued.

But the Society being of late years greatly inlarged, and their communications more numerous, it was thought adviſeable, that a Committee of their members ſhould be appointed to reconſider the papers read before them, and ſelect out of them ſuch, as they ſhould judge moſt proper for publication in the future *Tranſactions*; which was accordingly done upon the 26th of March 1752. And the grounds of their choice are, and will continue to be, the importance and ſingularity of the ſubjects, or the advantageous manner of treating them; without pretending to anſwer for the certainty of the facts, or propriety of the reaſonings, contained in the ſeveral papers ſo publiſhed, which muſt ſtill reſt on the credit or judgment of their reſpective authors.

It is likewiſe neceſſary on this occaſion to remark, that it is an eſtabliſhed rule of the Society, to which they will always adhere, never to give their opinion, as a body, upon any ſubject, either of Nature or Art, that comes before them. And therefore the thanks, which are frequently propoſed from the chair, to be given to the authors of ſuch papers, as are read at their accuſtomed meetings, or to the perſons through whoſe hands they receive them, are to be conſidered in no other light than as a matter of civility, in return for the reſpect ſhewn to the Society by thoſe communications. The like alſo is to be ſaid with regard to the ſeveral projects, inventions, and curioſities of various kinds, which are often exhibited to the Society; the authors whereof, or thoſe who exhibit them, frequently take the liberty to report, and even to certify in the public news-papers, that they have met with the higheſt applauſe and approbation. And therefore it is hoped, that no regard will hereafter be paid to ſuch reports, and public notices; which in ſome inſtances have been too lightly credited, to the diſhonour of the Society.

CONTENTS

OF

VOL. LXIX. PART I.

I. *AN Account of the Cure of the St. Vitus's Dance by Electricity. In a Letter from* Anthony Fothergill, *F. R. S. M. D. at* Northampton, *to* William Henly, *F. R. S. Communicated by Mr.* Henly. p. 1

II. *A Caſe in which the Head of the* Os Humeri *was ſawn off, and yet the Motion of the Limb preſerved. By Mr.* Daniel Orred, *of* Cheſter, *Surgeon. Communicated by* Thomas Percival, *M. D. F. R. S. and A. S. and Member of the Royal Society of Phyſicians at* Paris. p. 6

III. *Experiments on ſome Mineral Subſtances. By* Peter Woulfe, *F. R. S. Communicated at the Deſire of* William Hunter, *F. R. S. and Phyſician extraordinary to the Queen.* p. 11

IV. *Account of a Petrefaction found on the Coaſt of* Eaſt Lothian. *By* Edward King, *Eſq. F. R. S.* p. 35

V. *Account of Dr.* Knight's *Method of making artificial Loadſtones. By Mr.* Benjamin Wilſon, *F. R. S.* p. 51

VI.

VI. *Account of an extraordinary Dropſical Caſe. By Mr.* John Latham, *in a Letter to Mr.* Warner, *F. R. S.* p. 54

VII. *Problems concerning Interpolations. By* Edward Waring, *M. D. F. R. S. and of the Inſtitute of* Bononia, Lucaſian *Profeſſor of Mathematics in the Univerſity of* Cambridge. p. 59

VIII. *Diſquiſitio de tempore Periodico Cometæ anni* 1770 *obſervati. Autore* J. A. Lexell, *Academiæ Scientiarum Petrop. Socio. Communicated by* Nevil Maſkelyne, *D. D. F. R. S. and Aſtronomer Royal.* p. 68

IX. *On the General Reſolution of Algebraical Equations. by* Edward Waring, *M. D. F. R. S. and of the Inſtitute of* Bononia, *Lucaſian Profeſſor of Mathematics in the Univerſity of* Cambridge. p. 86

XI. *Obſervations on the total (with Duration) and annular Eclipſe of the Sun, taken on the 24th of* June, 1778, *on Board the* Eſpagne, *being the Admiral's Ship of the Fleet of* New Spain, *in the Paſſage from the* Azores *towards* Cape St. Vincent's. *By Don* Antonio Ulloa, F. R. S. *Commander of the ſaid Squadron; communicated by* Samuel Horſley, *LL.D. F. R. S.* p. 105

XII. *Tentamen continens Theoriam Machinæ ſublicarum. Autore* Thoma Bugge, *Aſtronomo Regio, Aſtron. et Mathem. Prof. in Academia* Havnienſi, *e Societatibus Scient.* Havnienſ. *et* Nidroſ. *Communicated by Sir* John Pringle, *Bart. F. R. S.* p. 120

XIII. *Account of an Iconantidiptic Teleſcope, invented by Mr.* Jeaurat, *of the Academy of Sciences of Paris. Com-*

municated by John Hyacinth de Magellans, *F. R. S.* p. 130

XIV. *Account of the Organs of Speech of the* Orang Outang. *By* Peter Camper, *M. D. late Profeſſor of Anatomy, &c. in the Univerſity of* Groningen, *and F. R. S. in a Letter to Sir* John Pringle, *F. R. S.* p. 139

XV. *Account of the Effects of Lightning on Board the* Atlas. *By* Allen Cooper, *Eſq. Maſter of the* Atlas *Eaſt India-man. In a Letter to* Joſeph Banks, *Eſq. P. R. S.* p. 160

XVI. *Extracts of Three Letters from* John Longfield, *M. D. at* Corke *in* Ireland, *to the Aſtronomer Royal, containing ſome Aſtronomical Obſervations; together with the Longitude of* Corke, *deduced from the ſaid Obſervations, by the Aſtronomer Royal.* p. 163

XVII. *The Latitude of* Madraſs *in the* Eaſt Indies, *deduced from Obſervations made by* William Stephens, *Chief Engineer. Communicated by* John Call, *Eſq. F. R. S.* p. 182

XVIII. *Account of an Infant Muſician. By* Charles Burney, *Doctor of Muſic and F. R. S.* p. 183

XIX. *Account of the Method of cultivating the Sugar Cane. By Mr.* Cazaud; *communicated by* Joſeph Banks, *Eſq. P. R. S.* p. 207

XX. *Account of the* Free Martin. *By* John Hunter, *Eſq. F. R. S.* p. 279

XXI. *Meteorological Journal kept at the Houſe of* The Royal Society, *by Order of the Preſident and Council.* p. 295

XIV. Account of the Organs of Speech of the Orang Outang. By Peter Camper, M. D. late Professor of Anatomy, &c. in the University of Groningen, and F. R. S. in a Letter to Sir John Pringle, P. R. S. p. 139

XV. Account of the Effects of Lightning on Board the Adas. By Alban Cooper, Esq. in a Letter to [illegible] p. 185

XVI. Extract of three Letters from John Lining, M. D. of Carolina, to the [illegible] p. 189

XVII. Account of an Inflammation of the Eyes, made by Mr. Oliver's Ointment. Communicated by John Coakley Lettsom, M. D. F. R. S. p. 193

XVIII. Observations on Inflammation. By Charles Blagden, M. D. F. R. S. p. 205

XIX. Account of the Fixed Nitre. By John Hunter, M. D. F. R. S. p. 279

PHILOSOPHICAL TRANSACTIONS.

I. *An Account of a Cure of the St. Vitus's Dance by Electricity. In a Letter from* Anthony Fothergill, *M. D. F. R. S. at* Northampton, *to* William Henly, *F. R. S. Communicated by Mr.* Henly.

SIR, Northampton, Oct. 28, 1778.

Read Nov. 5, 1778. AGREEABLE to my promiſe, I now proceed to give you ſome account of a recent cure performed by electricity, which will, I think, afford you much pleaſure.

ANN AGUTTER, a girl of ten years of age, of a pale, emaciated habit, was admitted an out-patient at the Northampton Hoſpital on the 6th of June laſt. From her father's account it appeared (for ſhe was ſpeechleſs and with difficulty ſupported from falling by two aſſiſtants) that ſhe had for ſix weeks laboured under violent convulſive motions, which affected the whole frame, from which ſhe had very ſhort intermiſſions, except during ſleep; that the diſeaſe had not only impaired her memory and intellectual faculties, but of late had deprived her of the uſe of ſpeech.

Volatile and fetid medicines were now recommended, and the warm bath every other night; but with no better ſucceſs, except that the nights which had been reſtleſs became ſomewhat more compoſed. Bliſters and anti-ſpaſmodics were directed, and particularly the flowers of zinc, which were continued till the beginning of July, but without the leaſt abatement of the ſymptoms; when her father growing impatient of fruitleſs attendance at the hoſpital, I recommended, as a dernier reſort, a trial of electricity, under the management of the Rev. Mr. UNDERWOOD, an ingenious electrician. After this I heard no more of her till the firſt of Auguſt, when her father came to inform me that his daughter was well, and deſired ſhe might have her diſcharge. To

which, after expreſſing my doubts of the cure, I conſented; but ſhould not have been perfectly convinced of it, had I not received afterwards a full confirmation of it from Mr. UNDERWOOD, dated Sept. 16, an extract from whoſe letter I will now give you in his own words.

"I have long expected the pleaſure of ſeeing you, "that I might inform you how I proceeded in the cure "of the poor girl. As the caſe was particular, I have "been very minute, and wiſh you may find ſomething "in it that may be uſeful to others. If you think it pro-"per, I beg you will ſtate the caſe medically, and make "it as public as you pleaſe.

"July 5. On the glaſs-footed ſtool for thirty minutes: "ſparks were drawn from the arms, neck, and head, "which cauſed a conſiderable perſpiration, and a raſh "appeared in her forehead. She then received ſhocks "through her hands, arms, breaſts, and back; and from "this time the ſymptoms abated, her arms beginning to "recover their uſes[a].

"July 13. On the glaſs-footed ſtool forty-five mi-"nutes: received ſtrong ſhocks through her legs and "feet, which from that time began to recover their "wonted uſes; alſo four ſtrong ſhocks through the jaws, "ſoon after which her ſpeech returned.

(a) The coated bottle held near a quart.

"July 23. On the glaſs-footed ſtool for the ſpace of "one hour: ſparks were drawn from her arms, legs, "head, and breaſt, which for the firſt time ſhe very ſen- "ſibly felt; alſo two ſhocks through the ſpine. She "could now walk alone; her countenance became more "florid, and all her faculties ſeemed wonderfully "ſtrengthened, and from this time ſhe continued mend- "ing to a ſtate of perfect health.

"Every time ſhe was electrified poſitively, her pulſe "quickened to a great degree, and an eruption, much "like the itch, appeared in all her joints."

Thus far Mr. UNDERWOOD. To complete the hiſtory of this ſingular caſe, I this day (Oct. 28) rode ſeveral miles, on my return from the country, to viſit her; and had the ſatisfaction to find her in good health, and the above account verified in every particular, with this addition, that at the beginning of the diſeaſe ſhe had but ſlight twitchings, attended with running, ſtaggering, and a variety of involuntary geſticulations which diſtinguiſh the St. Vitus's dance, and that theſe ſymptoms were afterwards ſucceeded by convulſions, which rendered it difficult for two aſſiſtants to keep her in bed, and which ſoon deprived her of ſpeech and the uſe of her limbs. The eruptions which appeared on the parts electrified ſoon receded, without producing any return of the ſymptoms,

ſymptoms, and therefore could not be called critical, but merely the effect of the electrical ſtimulus. Having given her parents ſome general directions as to her regimen, &c. I took my leave, with a ſtrong injunction to make me acquainted in caſe ſhe ſhould happen to relapſe. Before I conclude, it may not be improper to obſerve, that ſome time ago I was fortunate enough to cure a boy who had long had the St. Vitus's dance (though in a much leſs degree) by electricity. A violent convulſive diſeaſe, ſomewhat ſimilar to the above, though, if I recollect right, not attended with the *aphonia*, was ſucceſsfully treated in the ſame way by Dr. WATSON, and is recorded in the Philoſophical Tranſactions. May we not then conclude, that theſe facts alone, and more might perhaps be produced, are ſufficient to intitle electricity to a diſtinguiſhed place in the claſs of antiſpaſmodics?

I am, &c.

II. *A Case in which the Head of the* Os Humeri *was sawn off, and yet the Motion of the Limb preserved. By Mr.* Daniel Orred, *of* Chester, *Surgeon. Communicated by* Thomas Percival, *M. D. F. R. S.* and *A. S. and Member of the Royal Society of Physicians at* Paris.

SIR, Manchester, Sept. 20, 1778.

Read Oct. 12, 1778. A VERY eminent surgeon at Chester has desired me to transmit the inclosed case to the Royal Society, and I hope it will be deemed worthy of publication. It not only affords a confirmation of an important fact inserted in the Philosophical Transactions, vol. LIX. art. VI.; but shews also that the chirurgical improvement, proposed in that article by my ingenious friend Mr. CHARLES WHITE, may be extended to operations on other parts of the human body.

I am, &c.

THO. PERCIVAL.

A FRIEND

A FRIEND of mine, an ingenious ſurgeon, ſettled at Tarporley, in this county, ſent for me about the middle of laſt month to ſee a patient of his, a gentleman's ſervant in that neighbourhood. This was a man of about forty years of age, who had much injured a good conſtitution by hard drinking before the following accident happened to him.

From an injury received more than three years before the time I ſaw him, by a fall from the top of a ladder, I found a ſuppuration had taken place in the ſhoulder joint. The matter had made its way through three ſmall openings; one in the *axilla*, directly oppoſite to the cavity of the joint; the other two lower than the ſtrong tendons of the pectoral muſcle, and betwixt the *deltoides* and *biceps* muſcles. Upon introducing a probe into the joint by the upper orifice, I found the head of the *os humeri* exceedingly carious. A few weeks before I ſaw him, a collection of matter had formed upon his foot, I ſuppoſe from an abſorption and tranſlation from the ſhoulder. Upon letting out the matter with a lancet, I found the metatarſal bones alſo very carious: with theſe ſhocking complaints no wonder he was much enfeebled and reduced. As the diſeaſe in his ſhoulder would evidently ſoon have put a period to his life without immediate relief, I propoſed to him,

him, either to amputate the arm at the diſeaſed joint, or, with a view of making it of ſome uſe to him, endeavour to ſaw off the head of the affected bone only. As the leaſt of two evils he choſe the laſt; though this indeed is a moſt painful, hazardous operation. We are indebted to Mr. WHITE, of Mancheſter, for the mode of this operation, as well as for many other valuable hints and diſcoveries in ſurgery. In order to allow the arm as much action as poſſible after the operation, I began my inciſion a little above the joint, and continued it in a right line directly through the middle of the fleſhy portions of the *deltoides*, and a little lower than its inſertion: then elevating the arm to relax the muſcle, an aſſiſtant with both hands diſtended the upper part of the opening made by the inciſion, whilſt, with a narrow knife, I endeavoured, by the direction of the fore-finger of the left hand, carefully to divide the capſular ligament. This was effected with very great difficulty, as from preceding inflammation it was much thickened, and adhered cloſely to the joint: and till it was ſeparated nearly round (for the under, and moſt dangerous part to cut through, was corroded with matter) I found my utmoſt efforts to throw the head of the bone out of its ſocket quite ineffectual. After a ſufficient ſeparation I made the diſlocation, by preſſing the elbow to the body with one hand, and with the

the other pulling the head of the *humerus* directly towards me. After guarding the great artery againſt the action of the ſaw, by introducing a piece of paſte-board under the bone, I ſeparated it acroſs, as Mr. WHITE directs, as low down as I poſſibly could to prevent an exfoliation. The loſs of blood was very trifling. After dreſſing the wound very ſuperficially, I took particular care that the artery was not preſſed upon by the bandages; and adviſed, when the inflammation ſubſided, and a good digeſtion came on, that his arm ſhould always be dreſſed when the body was erect, and ſuſpended a little from it, with the fore arm a little bent: this was accordingly done. In a few days after the operation, he got up, and continued to ſit up the day through ever after. He had a cold infuſion of the Peruvian bark with the weak ſpirit of vitriol ordered him. In conſequence of his very reduced habit of body, his ſhoulder was long in curing. A ſmall exfoliation took place. The cure, I fancy, was alſo much retarded by the diſeaſed foot, which ſtill continued very bad; the man being ſo exceedingly terrified by the former operation, that he would not ſuffer us to do any thing to any purpoſe to it.

I ſaw him about three months after the accident. The wound was nearly cicatrized; but the oſſification was not ſo far advanced as I expected it would have been, the

callus being much ſmaller than the lower part of the *humerus*, and bending with the weight of the arm. However, he could raiſe it from his body more than could be well ſuppoſed, and had the perfect flexure and uſe of his fore arm. This caſe, with all the diſagreeable circumſtances attending it, ſtrongly proves the utility of the above operation. By a ſimilar operation diſeaſes of other joints may be as eaſily cured.

About five years ago, a young man of the name of MOORES, about ſixteen years of age, and ſon to a farmer at Alderſey, a village in this neighbourhood, applied to me with a diſeaſe in the lower part of the *ulna*, where it joins the bones of the *carpus*. A variety of means for ſeveral years had been tried to no purpoſe, to relieve him before he came to me. The patient was of a good habit of body, and ſeemed to enjoy tolerable good health. With his conſent I carefully ſeparated from the adjoining parts, and ſawed off, more than three inches of the enlarged bone. A *callus* at a proper time formed in the intermediate ſpace. He is now able to undergo the moſt laborious parts of huſbandry buſineſs; though that part of the fore arm where the operation was performed is ſtill ſomething ſmaller than the ſame part in the other arm.

III. *Experiments on ſome Mineral Subſtances.* By Peter Woulfe, *F. R. S. Communicated at the Deſire of* William Hunter, *F. R. S. and Phyſician extraordinary to the Queen.*

Read Nov. 19, 1778.

On cryſtal, quartz, and flint.

MONS. BEAUMÉ, a member of the Royal Academy of Sciences of Paris, has aſſerted, that he obtained allum from cryſtal, quartz, and flint. His method to obtain allum from theſe ſubſtances was to make a *liquor ſilicum*, by melting them in a crucible with fixed alkaly, and letting the mixture run *per deliquium*; any acid added to this *deliquium* precipitates the cryſtal, quartz, or flint, which, by means of acid of vitriol, he diſſolved, and obtained allum. I have often repeated this operation on all theſe ſubſtances, but could never obtain a ſingle grain of allum: in lieu thereof I got a ſelenite, and was on that account convinced, that the baſis of theſe ſubſtances was a calcareous earth. Mr. BEAUMÉ's miſtake was, I am certain, owing to the Paris crucibles which he

made uſe of, and which, for want of being well burnt, retained yet their clayey nature; conſequently a portion, and that not a ſmall one, of the clay, is diſſolved by the alkaly; allum muſt therefore in his manner be obtained, as clay is the matrix, or at leaſt contains the earth of allum. It is rather a tedious operation to make the *liquor ſilicum*, and eſpecially in any quantity; for the mixture is very ſubject to froth and boil up in the crucible, and the operation is not compleat until this boiling up ceaſes, and the mixture melts thin. Hence it is natural to conclude, that a large portion of the clay of a Paris crucible is diſſolved by the alkaly during this long operation.

In order to diſcover whether the cryſtal, quartz, or flint, contained any acid, I put in practice the method which I publiſhed in my laſt paper on mineral ſubſtances, to diſcover the acids of horn ſilver and horn mercury; but I could not find they contained any.

On the change of cryſtal into ſelenitical ſpar.

The cryſtal on which I tried the following experiments, and which is partly changed into ſelenitical ſpar, is to be found in that moſt excellent muſeum collected by Dr. HUNTER. This cryſtal comes from near Freyberg in Saxony, and is called in German *nieren-formiger cry-*

ſtal (kidney-formed cryſtal). It is in the form of an uneven cruſt, with ſmall protuberances; a part of it retains all the appearances of cryſtal, but the reſt is opaque, ſomewhat of an aſh colour, and is eaſily powdered: the underpart retains marks of *galena* or potter's lead ore, and in ſome ſpecimens the greateſt part is coated with it.

I took three drams of the opaque part of this cryſtal finely powdered, and mixed it with an equal quantity of fixed alkaly of cream of tartar, and in order to facilitate the union, the mixture was made into a paſte with diſtilled water, then dried and calcined for an hour as in my experiments on horn ſilver (ſee Phil. Tranſ. vol. LXVI. p. 604.). The mixture was then taken out of the phial powdered, and, by digeſtion with diſtilled water at three different times, deprived of its ſaline part: theſe three ſolutions were mixed together, ſaturated with diſtilled vinegar, evaporated to dryneſs and waſhed well with rectified ſpirit of wine. By this means ℥j. and gr. vi. of tartar of vitriol was obtained. The undiſſolved part, remaining after digeſtion with water, when dried weighed ℥ij. and gr. xxiv.; this was mixed and digeſted with pure acid of nitre, and effervеſced ſtrongly. After this digeſtion the undiſſolved part here remaining, being well waſhed and dried, weighed ℥j. and gr. xv. which I take to be cryſtal, for no ſaline matter was obtained by treating it

it with acid of vitriol; and hence it appears, that nearly two-thirds of the cryſtal is changed into ſelenitical ſpar. The ſolution which was obtained by the acid of nitre mixed with acid of vitriol, but eſpecially with a ſolution of tartar of vitriol, precipitates copiouſly, and forms a ſelenite. This evidently proves the exiſtence of the calcareous earth, and the tartar of vitriol mentioned above, that of the acid of vitriol in this altered cryſtal.

The unaltered part of this cryſtal, treated in the ſame manner as the altered part, afforded no marks of ſelenitical ſpar.

The change of this cryſtal is, I ſuſpect, owing to the lead ore which adheres to it; the ſulphur of the lead ore furniſhing the acid of vitriol, and the cryſtal the calcareous earth.

I have in the above manner treated a variety of the heavy ſpars, commonly called ſelenitical or gypſeous ſpars, and found them all, as I firſt judged by their appearance and great weight (without being once miſtaken) to conſiſt of acid of vitriol, with calcareous earth and ſome clayey matter. In ſome, the calcareous earth was combined with a larger portion of this acid than in others; and in ſome, the clayey matter was predominant. Among theſe were the following, ſome of which were not before taken for ſelenitical ſpars.

The Derbyſhire and Eckton cauk, which is commonly covered with copper marcaſſite.

Ditto from Saxony, which is found growing like knobs or protuberances on the yellow phoſphoric ſpars.

The *ſpathum ericæ forme* of Woodward from Derbyſhire.

The ſtellated ſpar, which is found on the *ludus helmontii* from the iſland of Sheppy.

The ſpar from Saxony, reſembling lead ore, and which by many is ſuppoſed to be one, called in German *ſtangen ſpath*. This ſpar is by Baron BORN claſſed with the baſaltes; he has no doubt taken it for a ſhirl, which is claſſed with the baſaltes, but I never found them to have any affinity.

Another ſpar from Saxony, called alſo *ſtangen ſpath*, compoſed of large interwoven priſms, partly red and partly white, and ſemi-tranſparent.

Compact ſemi-tranſparent Auvergne ſpar, ſaid by M. MONET to contain ſulphur; but I could never find an atom of it in this or in any of the other ſpars I tried, and ſuppoſe his miſtake to be owing to a portion of charcoal, flame of charcoal, or duſt, that got into the crucible. Native ſulphur is frequently found growing with calcareous ſpar and gypſum, but it ſhould be conſidered as heterogeneous.

Flaky milk-white ſpar, found with Cobalt and copper ores from Saalfeld.

Two-

Two ſpars from the Hartz, compoſed of flakes and cryſtallized.

Ditto from Saxony.

Striated ſpar from Scotland, brought here by Mr. GOAN.

Spar intermixed with cinnabar and ochre of iron from Obermoſchel in the dutchy of Deux Ponts.

Red ochry compact ſpar from Derbyſhire.

I ſhall give a few of my experiments on theſe ſubſtances compared with the common Paris montmartre plaſter ſtone; all theſe were deprived of their humidity before they were ſubmitted to trial.

Two drams of the Paris plaſter ſtone, treated as in the former experiment, with an equal quantity of alkaly of tartar, produced ℥ jiſſ. and gr. viii. of tartar of vitriol[a].

The inſoluble part remaining after being deprived of its ſaline part by water, was digeſted with diſtilled vinegar, which effervеſced and diſſolved the whole of it, except a ſmall portion, which, when waſhed and dried, weighed gr. vi. and had the appearance of tobacco-pipe clay. Had I taken a pure white tranſparent gypſum, I believe that no ſediment would have been left. From

(a) The tartar of vitriol, of all the trials I make mention of in this paper, was diſſolved in diſtilled water, and mixed with a ſolution of calcareous earth in acid of ſalt, which cauſed a copious ſelenitical precipitation, a clear demonſtration of the exiſtence of the acid of vitriol.

this

this experiment it appears, that gr. xcviii. of vitriol was produced by gr. cxiv. of pure gypſum, for the gr. vi. of clayey matter muſt be deducted.

The like quantity of Derbyſhire cauk, treated in the ſame manner, produced gr. lix. of tartar of vitriol, and the clayey matter, which exactly reſembled the former, weighed gr. xxiii.

The ſtellated ſpar from the iſland of Sheppy, ſubmitted in the ſame proportion to the ſame trials as the foregoing, produced gr. lviii. of tartar of vitriol, and gr. xxii. of clayey matter, which was whiter than in the former.

WOODWARD's *erica* formed ſpar in the like proportion and manner as the former, afforded gr. xxxviii. of tartar of vitriol, and gr. xlii. of clayey matter.

To ſhew that the calcareous earth in the gypſum contained a greater portion of acid of vitriol than that in the ſelenitical ſpars, I reaſoned thus, having previouſly ſubtracted the clayey matter of each.

If 114 grains of plaſter (the 6 grains of clay being deducted) afford 98 grains of tartar of vitriol, how much ſhould 97 grains of the gypſeous matter contained in cauk afford (for the clayey ſubſtance muſt alſo here be ſubtracted). From this rule it ſhould produce $83\frac{12}{57}$ grains of tartar of vitriol, and nevertheleſs the quantity

was only 59 grains. Hence it is clear, that the calcareous earth of the gypſum contains a greater proportion of acid of vitriol than that of the cauk.

According to this rule, the ſtellated ſpar from Sheppy ſhould have afforded $84\frac{14}{37}$ grains of tartar of vitriol, but it produced only 58 grains.

The *erica*, formed ſpar by the ſame rule, ſhould have afforded $65\frac{17}{37}$ grains of tartar of vitriol, but the quantity was only 38 grains.

As I ſuſpected that the ſelenitical ſpars contained ſome calcareous earth, not united to the acid of vitriol, I digeſted ſome of them with rectified pure acid of nitre, and afterwards well waſhed and dried them; but the loſs of weight was very trifling, except in the cauk and *erica* formed ſpar; the firſt probably containing ſome marcaſſitical particles of copper, and the laſt an ochre of iron.

Dr. LEWIS, in his tranſlation of NEWMAN's Chemiſtry, quotes from the Philoſophical Tranſactions ſomewhat remarkable about cauk, that when wetted with antimony it gives it a ſhining ſurface like ſteel.

I repeated the experiment as follows: I powdered and mixed ℥ ſſ. of cauk with ℥ iij. of antimony, and put the mixture into a red hot crucible; and when melted, which readily happens, I ſtirred it with an iron rod, and poured

it

it into an iron mortar. This matter in its fracture has appearances of RULANDUS's falſe liver of antimony.

I have alſo tried, in the ſame proportion and manner, the following ſubſtances, and found the effects ſo much alike, that they could be ſcarcely diſtinguiſhed one from the other.

Stellated ſpar, from the iſland of Sheppy.

Auvergne compact plated ſpar.

Erica formed ſpar.

Whited plated gypſum dried.

Dried whiting.

Fixed alkaly of tartar.

Hence we may conclude, that the calcareous earth of theſe ſpars and gypſum act on the antimony like fixed alkaly, forming a ſort of liver of antimony.

Of ſome mineral ſubſtances which contain the earth of allum.

Tobacco-pipe clay, of all ſubſtances I know, would be the fitteſt to make allum with, was it neceſſary; but nature has ſupplied it abundantly in other bodies, from which it is obtained with little art and expence.

Two drams of dried tobacco-pipe clay, treated with an equal quantity of fixed alkaly of tartar, as in the laſt ex-

periments, produced no tartar of vitriol; nor have I been able to obtain any from the other clays, which I ſubmitted to the ſame trials: ſuch were the porcellane clay from Cornwall, the porcellane clay from Saxony, Sturbridge clay, fuller's earth, as alſo the blue argilla from Paris, which M. BEAUME ſays is replete with the acid of vitriol[b], and to that he attributes its property of ſetting free the acids of ſalt petre and of ſea ſalt; but of this more fully hereafter.

The tobacco-pipe clay, having been deprived of its ſaline part after the calcination, was as white as chalk, and had loſt its tenacity[c]. It increaſed in weight gr. viii. and the alkaly was not only diminiſhed in weight, but was alſo combined with a portion of the clay; for, on ſaturating it with diſtilled vinegar, a gelatinous ſubſtance was ſeparated. I have often obſerved the formation of this gelatinous matter on the ſurface of the Vauxhall ſtone bottles, in which I had kept for ſome months

(*b*) M. BEAUME, in order to demonſtrate the acid of vitriol in the clay, has boiled it for a conſiderable time with fixed alkaly, and thereby obtained tartar of vitriol: had he made uſe of a pure alkaly, I would take upon me to ſay, that his experiment would have failed. The alkaly he uſed contained already tartar of vitriol, which became more manifeſt by long boiling, as a portion of the alkaly combines with the clay.

(*c*) Might not this be ſubſtituted in the room of white lead for painters uſe, the white lead having many bad qualities, and being very injurious to ſome other colours?

oil

oil of tartar, *per deliquium*. This ware is made with tobacco-pipe clay and ſand, and when well burnt is not acted on by either acids or alkalies.

This ſhews the union of clay with alkalies, and that may be the chief reaſon why it ſhould, when helped with heat, be ſo uſeful in obtaining the acids of nitre and of ſea ſalt. I have alſo obtained this gelatinous ſubſtance by mixture of tobacco-pipe clay and oil of tartar, *per deliquium*; for after ſome months, the alkaly being diſſolved with water and evaporated, had in great part a gelatinous conſiſtence. This mixture was ſtirred now and then, and had a remarkable volatile alkaline ſmell. Mr. BOYLE ſays, that clays diſtilled with ſea ſalt produces a *ſal ammoniac*, and I found it to be always true when the diſtillation is at firſt ſlowly conducted.

I have often made allum with tobacco-pipe clay calcined with oil of vitriol, but kept no notes of the quantity I obtained; and as for the *reſiduum* uſed in this experiment, it was loſt. I can, however, tell the quantity of allum which the porcellane clay from Cornwall affords. Two drams of this clay, which had been treated with its weight of fixed alkaly, and deprived of its ſaline part, then calcined four different times, with a freſh portion each time of oil of vitriol, produced ℥ ſſ. and gr. xxiv. of good

good cryſtallized allum[d]. The fourth calcination afforded no allum, and what remained, after being dried and waſhed, weighed gr. lv. What this matter is I have not yet tried; perhaps it may be of the quartzy kind. Hence it appears, that this clay contains half its weight of earth of allum, which, by its union with the acid of vitriol and the water that enters into its cryſtallization, produces better than four times its weight of allum, and therefore this clay treated with acid of vitriol affords more than double its weight of allum.

Of Feld ſpar.

The honourable Mr. GREVILLE, a member of the Royal Society, and remarkable for his taſte and ſkill in natural hiſtory, as well as for his judicious remarks on the nature, growth, and formation of minerals, has in his travels made ſome very intereſting obſervations on the formation of Feld ſpar; the ſpecimens which he collected on the ſpot ſhew evidently the change of clay into this ſpar, and alſo the different gradations of the change.

(d) The celebrated Mr. MARGRAF, to whom the diſcovery of making allum with *argilla* and acid of vitriol is due, could not obtain the allum in a cryſtallized ſtate without the addition of ſome fixed alkaly. His miſtake was owing to the exceſs of acid of vitriol, which the alluminous earth of the clay retained for want of ſufficient heat, and which he corrected by ſaturating it with an alkaly.

The

The Feld ſpar I made uſe of was given me by that moſt excellent chemiſt, M. ROUELLE of Paris, and I think he told me it came from Alençon.

In order to make allum of it, I melted ℥ j. of it with ℥ j ſſ. of fixed alkaly of cream of tartar, and let the mixture run *per deliquium*. This operation is as tedious and as troubleſome to perform as the *liquor ſilicum* made with flint, quartz, or cryſtal, for it is as liable to froth and boil over. No neutral ſalt was here obtained. The *deliquium* with its dregs were mixed with diſtilled vinegar, which precipitated the ſpar: this precipitate, after edulcoration and exſiccation, was calcined four different times, with freſh parcels each time of oil of vitriol, and afforded ℥ vij. and gr. xvi. of good and regularly cryſtallized allum; the part which afforded no more allum, when waſhed and dried, weighed ʒ j. and ϑ ij.

The Labradore ſtone (*a*) is alſo a Feld ſpar, though not ſo hard as the former. The like quantity of this, treated as the foregoing, gave no marks of neutral ſalt; the quantity of allum was ℥ j. ʒ j. and gr. xii.; and the un-

(*a*) This ſtone is only found on the Coaſt of Labradore, and was brought here by the direction of the Rev. Mr. LA TROBE, remarkable for his piety and zeal in propagating the goſpel among the ſavage Indians. This ſtone reflects a variety of fine ſhining colours, ſuch as blue, green, yellow, &c. I doubt not but that ſeveral other ſtones, which reflect various and changeable colours, upon trial will be found to be Feld ſpars.

diſſolved part weighed ʒ v. and gr. xxxvi. This ſpar does not boil up in its fuſion with the alkaly near ſo much as the other, and therefore the loſs in the operation is trifling compared to it, and on that account it affords a greater proportion of allum.

Shirl frequently, though erroneouſly, called baſaltes.

The ſhirl I tried is of a brown colour, forms a maſs of long minute priſms cloſely adhering together, and comes from Bohemia. Its brown colour is owing to iron. This ſhirl, treated in the ſame proportion and manner as the Feld ſpar, afforded no neutral ſalt. The quantity of allum was ʒ ij. ʒ j. and gr. xxiv.; but I muſt obſerve, that the two laſt cryſtallizations contained iron, and the mother water that remained was of an oily conſiſtence, had a ſtyptic taſte, and reſembled that obtained in making green copperas. The earthy matter here remaining weighed ʒ ij. and gr. lii; was light and of a grey colour. Hence it is evident, that ſhirl contains nearly as much earth of allum as the Corniſh porcellane clay.

Mr. ILSEMAN, an ingenious apothecary and chemiſt at Clauſthal in the Hartz, has aſſured me, that he obtained from pumice ſtone and ſhirl a *ſal catharticus amarus*. He has, I preſume, made his trials on ſhirl

which is found with lava, and is the product of a volcano. I had none of it to try, but judge it, from its appearance, to be of a different nature from that found in mines.

Allum is commonly obtained from ſlate, which for that purpoſe is calcined for a conſiderable time. I know no ſubſtance ſo replete with it as the Iriſh ſlate, *lapis Hybernicus* of the druggiſts; for this, without any calcination, affords allum.

Allum is likewiſe obtained from the earth or clay of Solfatara, and from the red ſlate found near Saarbruck; but theſe have been expoſed, no one can tell how long, to the heat of volcanos. Iron always accompanies allum, and thence the uſe of ſome alkaly, by which means the red chalk *(rubrica fabrilis)* is obtained.

Of jaſper.

Many of the jaſpers, ſo called, owe their origin to cryſtal or quartz coloured with iron; perhaps in a few inſtances to copper. Theſe, I dare ſay, treated as the former, would produce no allum; but I have only tried one of the Oberſtein jaſpers, and this had viſible marks of cryſtal. Others of the jaſpers, and theſe I call the true ones, are formed by clay and afford allum; ſuch is the

Saxon jaſper, called ribbon agate, as alſo a red one, which was given me as coming from Johngeorgenſtadt. From thoſe I obtained very good allum, but can give no account of the particulars, having loſt the paper which contained the reſult of my experiments.

Yellow pitch ſtone, and wood like dale, petrified with pitch ſtone, both from Hungary.

The reſult of my experiments on theſe ſubſtances was ſet down on the ſame paper with that of the jaſpers which was loſt; but I recollect to have only obtained a ſmall portion of allum, and for that purpoſe was obliged, before I obtained the allum well cryſtallized, to waſh away the exceſs of acid with rectified ſpirit of wine.

Tin ſpar of the Germans, *commonly called white tin ore.*

It has a ſparry appearance; but by its lamellated texture and great ſpecific gravity, which is equal to that of tin grains, is eaſily known. This is ſuppoſed by ſeveral to be rich in tin; but the Saxon mineralogiſts aſſert, that it contains none. The only experiment I made with it was to digeſt it in a powdered ſtate with acids, by which means it acquires a rich yellow colour, like turbith mi-

neral; the acid of ſalt anſwers beſt for this experiment. This is the only ſubſtance I know of which has this property.

Norway zoolite.

This ſubſtance, treated with fixed alkaly, as in the former experiments, afforded no neutral ſalt; and what remained, after the alkaly was waſhed away, treated with acids, formed the like gelatinous matter as it does in its crude ſtate.

An account of ſuch ſubſtances as have a ſparry appearance, and how to diſtinguiſh the one from the other.

Cryſtal and quartz are eaſily known by their great hardneſs, and by the copious ſparks of fire which they afford when ſtruck with ſteel.

Feld ſpar is frequently ſo hard as to ſtrike fire with ſteel, and to give copious ſparks of fire; but its laminated texture, as well as its breaking into rhombs, makes it eaſily diſtinguiſhed from cryſtal and quartz.

Phoſphoric ſpar is eaſily known by the luminous appearance it has when heated, and alſo by the ſmell it

affords when added to oil of vitriol made hot, which exactly reſembles that of acid of ſalt. It is found of various colours, as green, blue, purple, crimſon, white, and alſo yellow. When cryſtallized it forms perfect cubes; the only exception I ever met with was a ſpecimen of the green ſort, which was ſent me by Mr. SOPER, of St. Columb in Cornwall, who has diſtinguiſhed himſelf by his ſkill in natural hiſtory and mineralogy. This ſpecimen was compoſed of two quadrangular pyramids united together at their baſis.

Selenitical ſpar is found cryſtallized in a great variety of forms; is heavier than the foregoing ſubſtance; does not effervеſce or diſſolve with acids, nor is it ſo hard as the phoſphoric ſpar.

Calcareous ſpar is eaſily diſtinguiſhed from other ſubſtances by its effervеſcences and ſolution in the acids of nitre and ſea ſalt. Acid of vitriol, added to theſe ſolutions, cauſes a ſelenitical precipitation: this ſpar is neither ſo hard nor ſo heavy as the foregoing ſubſtances, and cryſtallizes in a great variety of forms.

Gypſum is lighter than any of the foregoing ſubſtances, and is ſo ſoft as to be eaſily ſcratched with one's nail; it does not effervеſce nor diſſolve with acids, and is the only ſubſtance that forms plaſter when burnt; it cryſtallizes in a great variety of forms.

Mica or Glimmer. This is lighter than any of the ſparry ſubſtances; is compoſed of very thin flexible flakes, more or leſs large. Many of this kind are found in form of ſmall coloured ſcales of various colours, and very much reſemble the bronzes.

Tin ſpar, or white tin ore, ſee its deſcription heretofore.

White lead ore is found of a great variety of forms; is very heavy, effervesces with the acids of nitre and ſea ſalt, and totally diſſolves in them, with the help of heat. With the acid of ſalt it forms cryſtals much reſembling a ſilver coloured glimmer, juſt as common lead would have done, and with the acid of nitre it forms regular cryſtals.

The ſpathoſe iron ores, when powdered and put on a red-hot iron or ſtone, inſtantly become black, and look like a black, ſhining, micaceous iron ore.

Zeolite is lighter than the calcareous ſpars: ſee its properties already deſcribed.

Of a ſet of ſpars whoſe properties were not hitherto known, and experiments made on one of them.

This ſpar cryſtallizes in form of flat, and alſo of ſolid, rhomboidal cryſtals, and is found of a great variety of colours, ſuch as white and ſemi-tranſparent, of a pearl colour,

colour, reddiſh, and of different ſhades of brown and yellow, ſome of them being like gold, braſs, and copper. It has always a peculiar gloſs or brightneſs. May not the green and yellow glimmers from Johngeorgenſtadt be of this kind?

The ſpecimen I made uſe of for the following experiments is in Dr. HUNTER's collection, and ſeemed to be well adapted for this purpoſe, it being perfectly free from any matrix or heterogeneous matter. The whole ſubſtance of it is a cruſt compoſed of rhomboids, which grow out of one another, and form a variety of cavities: its colour is white and ſemi-pellucid, and on one ſide there was a ſlight marcaſitical coating. This ſubſtance comes from Joachimſthal, and is harder than any of thoſe mentioned before, except the cryſtal, quartz, and feld ſpar.

EXPERIMENT I.

Three drams of this ſpar, with an equal quantity of fixed alkaly of cream of tartar, melt with a moderate degree of tin; but the mixture ſoon becomes thick and cakes. It was after an hour's calcination ſuffered to cool, then was powdered and deprived of its ſaline part with boiling diſtilled water. This ſaline part, treated as in the other

other experiments with diſtilled vinegar and rectified ſpirit of wine, gave no marks of neutral ſalt. The undiſſolved part after this operation dried, weighed ʒ ij. and gr. l.: this was mixed with oil of vitriol, which cauſed a ſtrong effervescence, and then calcined, to be deprived of its exceſs of acid. It was now digeſted, at three different times, with diſtilled water, which diſſolved a portion of it; what remained undiſſolved after this operation, being dried, weighed ʒ j. and gr. lii. and was a ſelenite, as will appear by further experiments. The three portions of water, with which this matter was digeſted, mixed together, then evaporated and cryſtallized, produced ʒ ij. and gr. xlv. of a white ſalt, moſtly conſiſting of rhomboidal priſms, ſome lying flat and ſome erected ſideways. This I judged, by its ſtyptic taſte, to contain iron, and by its white colour to contain a *ſal catharticus amarus*, or at leaſt a new earth, which with the acid of vitriol forms a ſoluble ſalt.

EXPERIMENT II.

This ſpar, in its crude ſtate, effervesces ſtrongly with oil of vitriol diluted with water. Three drams of the ſpar treated in this manner, and afterwards deprived by calcination of its exceſs of acid, and then of its ſaline part by diſtilled

diſtilled water, left a ſelenite, which when dried weighed ℥ij. and gr. xx. This proportion is greater than in the former experiment, which I attribute to the acid of vitriol having been diluted with water, and its combining on that account in a greater quantity with the calcareous earth of the ſpar. The ſaline part by evaporation and cryſtallization produced ℥ij. and gr. xxviii. of ſalt, compoſed of ſmall long cryſtals, like Epſom ſalts; it taſte was bitter and ſtyptic.

This ſpar, in its natural ſtate, effervesces ſtrongly with rectified acid of ſalt, produces heat, and totally diſſolves in it; the ſolution is of a fine yellow colour.

Rectified acid of nitre diſſolves alſo this ſpar with effervescence and heat; but the ſolution is colourleſs.

I judged from the foregoing experiments that this ſpar was compoſed of calcareous earth, ſome iron, and a portion of ſome other earth, which, with acid of vitriol, forms a ſoluble ſalt.

EXPERIMENT III.

In order to determine the quantity of calcareous earth this ſpar contained, I diſſolved three drams of it in rectified acid of ſalt, and by the addition of a ſufficient quantity of a ſolution of tartar of vitriol in water, I obtained a ſelenite,

a ſelenite, which, when waſhed and dried with a ſtrong heat, weighed ʒ iij. and gr. xxxvi.

Three drams of dried whiting, diſſolved in the ſame acid, and treated in the like manner, afforded ʒ iv. and gr. xviii. of ſelenite. The whiting was all diſſolved, except three grains. The calcareous earth contained in the ſpar muſt, by its formation into ſelenite, be increaſed in weight in the ſame proportion as the whiting; and hence it is evident, that three drams of this ſpar contains ʒ j ff. and gr. xix, of calcareous earth. The remaining part muſt be the earth above-mentioned, with ſome iron.

EXPERIMENT IV.

In order to judge of the quantity of iron that this ſpar contained (not having any more of it left) I took the ſalt of the firſt experiment, and diſſolved it with water, to which I added ſome acid of ſalt. I then precipitated the iron in form of Pruſſian blue with the common alkaline *lixivium* uſed for that purpoſe, and thereby obtained ſixteen grains of a fine deep-coloured blue. Acid of ſalt was added in the uſual manner, to heighten the colour, by which means nothing but iron was precipitated.

Two drams of common green copperas, treated in the ſame manner, produced ʒ j. leſs than two grains of the

ſame ſort of blue, though not ſo good. Hence we may conclude, that the ſalt of the firſt experiment, which was produced by three drams of ſpar with acid of vitriol, contained thirteen grains of vitriol of iron.

Pruſſian blue, made without help of allum, contains nearly half its weight of iron. Hence, from the foregoing experiments, three drams of this ſpar contain gr. viii. of iron, ʒ j. and gr. xlix. of calcareous earth, and ʒ j. gr. iij. of the earth of *ſal cathartícus amarus*, or perhaps ſome other earth, which forms, with acid of vitriol, a ſoluble ſalt.

The ſpathoſe iron ore being frequently found cryſtallized like the foregoing new ſpar, and having alſo a gloſs on it, I was willing to try whether it had any affinity with it; but by the following experiments it appears to be of a different nature, not containing any calcareous earth.

The ſpathoſe iron ore diſſolves almoſt totally in acid of ſalt, and the ſolution is of a deep yellow colour. A ſolution of tartar of vitriol in water added to it cauſes no precipitation; and hence it is evident, that it contains no calcareous earth. Acid of vitriol treated with the ſpathoſe iron diſſolves the whole of it, excepting a few dregs; another proof of its containing no calcareous earth. The acid of nitre diſſolves alſo this ſpar, and the ſolution is colourleſs.

IV. *Account of a Petrefaction found on the Coaſt of* Eaſt Lothian. *By* Edward King, *Eſq. F. R. S.*

TO SIR JOHN PRINGLE, BART. P. R. S.

SIR, John-ſtreet, November 14, 1778.

Read Nov. 26, 1778.

IN conſequence of the honour you did me, to put into my hands a very curious ſpecimen of a recent petrefaction, permit me now to offer to your conſideration a few thoughts concerning this production, which have occurred to me on comparing it with others of a ſimilar kind, and which may at leaſt ſerve as hints for further inveſtigation.

We ſhould not venture, it is true, without great caution, to ſpeculate on theſe matters, as haſty and ſpecious concluſions may eaſily be drawn by any one who indulges too readily a quick and lively imagination, which will ever be too ready to miſlead, rather than to procure ſolid information. But though I

am well aware of this danger, yet I venture to lay before you theſe few obſervations; and if you judge them at all worthy of attention, I would wiſh to communicate them, through your hands, to the Royal Society, for they are not made merely in conſequence of a ſlight and haſty ſurvey of this one ſpecimen, but are in truth concluſions that I have been led to form incidentally in the courſe of a very long inquiry, which I have been for ſome years purſuing on another occaſion; the reſult whereof I ſhall perhaps, if I live, hereafter communicate to the Society in a more full and explicit manner than the compaſs of a paper of this kind will permit.

The account of this ſpecimen, with which you favoured me, is as follows. In the year 1745, the Fox man of war was unfortunately ſtranded on the coaſt of Eaſt Lothian in Scotland, and there went to pieces; and the wreck remained about three and thirty years under water; but this laſt year a violent ſtorm from the North-eaſt laid a part of it bare, and ſeveral maſſes, conſiſting of iron, ropes, and balls, were found on the ſands near the place, covered over with a very hard ochry ſubſtance, of the colour of iron, which adhered thereto ſo ſtrongly, that it required great force to detach it from the fragments of the wreck. And, upon examination, this ſub-

ſtance appeared to be ſand, concreted and hardened into a kind of ſtone.

The ſpecimen now laid before the Society had been taken out of the ſea, from the ſame ſpot, ſome time before, and is a conſolidated maſs that had undergone the ſame change. It contains a piece of rope that was adjoining to ſome iron ring, and probably had been tied thereto. The ſubſtance of the rope is very little altered; but the ſand is ſo concreted round it, as to be as hard as a bit of rock, and retains very perfectly impreſſions of parts of the ring, juſt in the ſame manner as impreſſions of extraneous foſſil bodies are often found in various kinds of ſtrata.

Now, conſidering theſe circumſtances, we may fairly conclude, in the firſt place, that there is, on the coaſts of this iſland, a continual progreſſive induration of maſſes of ſand and other matter at the bottom of the ocean, ſomewhat in the ſame manner as there is at the bottom of the Adriatic ſea, according to the account given by Dr. DONATI[a].

And, in the next place (which is what more particularly deſerves our attention on this occaſion), it ſhould ſeem, that iron, and the ſolutions of iron, contribute very much to haſten and promote the progreſs of the concretion and induration of ſtone, whenever they meet and are

(a) See the Phil. Tranſ. vol. XLIX. p. 588.

united

united with thoſe cementing cryſtalline particles, which there is reaſon to believe are the more immediate cauſe of the conſolidation of all ſtones and marbles whatſoever, and which do very much abound in ſea water.

It would exceed the limits of this paper, were I to attempt here to mention only a ſmall part of the various facts that have come to my knowledge; and which have convinced me, and I truſt, when offered fairly to the conſideration of others, will make it appear fully to all that are attentive to theſe kind of reſearches, that there is, to this very day, a formation of ſtone, and even of marble itſelf, in certain places, in a much more perfect manner, than has been generally conceived; and far beyond what has been ſuppoſed, even by thoſe who have been ready too haſtily to account for ſuch a proceſs merely in conſequence of obſervations made on ſtalactitical and ſuch like ordinary concretions.

I ſhall not therefore preſume to trouble the Society, at preſent, with any detail of the inquiries I have made relating to that ſubject, though in reality they have been the foundation of the obſervations made in this paper; but ſhall confine my remarks merely to this one curious circumſtance; that wherever there is any induration and petrefaction of matter, from any cauſes whatever, it is greatly haſtened in its progreſs, and the conſolidation is rendered much more compleat and firm by being

being near any maſs of iron, and ſtill more ſo by the admixture of any ſolution of that metal.

This appears, in ſome degree, from the preſent ſpecimen; where, near adjoining to the ring, and in the portion of the fragment that has the largeſt impreſſion thereof, the concreted ſand-ſtone is of a firmer texture, and there is a larger cohering maſs formed about that part of the rope, than about thoſe parts that are further removed from the ring.

It appears alſo from a circumſtance that was particularly taken notice of when the wreck was diſcovered by the ſtorm this year (and which is mentioned, SIR, in the letter you favoured me with a ſight of); for the maſſes that were obſerved to have theſe concretions adhering to them, were not maſſes of timber, or other large fragments of the wreck, which one would think, on a ſlight conſideration of the matter, were moſt likely to cauſe obſtructions at the bottom of the ocean, and to form little banks of ſand, that might afterwards be concreted; but they were maſſes of looſe iron and ropes, and even of cannon balls, which were thus conſolidated.

The ſame concluſion alſo may be drawn, with ſtill more appearance of its being well founded, from a very remarkable piece of antiquity, which was diſcovered about three years ago on the coaſt of Kent. Some fiſhermen, ſweeping for anchors in the Gull ſtream (a part of

the ſea near the Downs), drew up a very curious old ſwivel gun, near eight feet in length. The barrel of the gun, which was about five feet long, was of braſs; but the handle (whereby it was to be turned or traverſed) which was about three feet in length, and alſo the ſwivel and pivot on which it turned, were of iron, and all round theſe latter, and eſpecially about the ſwivel and pivot, were formed exceeding hard incruſtations of ſand, converted into a kind of ſtone, of an exceeding ſtrong texture and firmneſs; whereas round the barrel of the gun, except where it was near adjoining to the iron, there were no ſuch incruſtations at all, the greater part of it being clean, and in good condition, juſt as if it had ſtill continued in uſe[b].

The incruſtation round the iron part of this gun was alſo the more deſerving of attention, becauſe it incloſed within it, and alſo held faſtly adhering to it on the outſide, a number of ſhells and corallines, juſt in the ſame manner as they are often found in a foſſil ſtate. There were plainly to be diſtinguiſhed, on the outſide of this maſs of incruſtation, pectens, cockles, limpets, muſcles, *vermiculi marini* and *balini*; and beſides theſe, one *bucci-*

(b) As there were ſeveral remarkable particularities in this gun, tending to explain ſome curious facts in hiſtory, I took the liberty to give a full account of it, with a view to illuſtrate them, in a memoir laid before the Antiquarian Society laſt year.

num

num[c] and one oyſter; and they were all ſo thoroughly and ſtrongly fixed thereto, and themſelves alſo converted into ſuch an hard ſubſtance, that it required as much force to ſeparate or break them, as to break a fragment off any hard rock; and in colour and appearance, they much reſembled ſome of the maſſes of foſſil bodies found near Chippenham in Wiltſhire.

This remarkable incruſtation, therefore, thus confined to the parts of the gun adjoining to the iron, and appearing no where elſe upon it, plainly indicates, that the iron was, by ſome means or other, the more immediate cauſe thereof: and yet it is to be obſerved, that in this inſtance the iron was very little diſſolved; for although it is manifeſt, from ſome circumſtances in its hiſtory, that the gun muſt have remained in the ſea above two hundred years, and probably a great deal longer, yet the greater part of the handle and of the ſwivel remained entire, and even the point of the pivot was undiſſolved, and very viſible.

Another curious appearance alſo, of a ſimilar nature, will tend further to confirm the obſervations here made. This is found in a ſpecimen (now in my poſſeſſion) of a moſt remarkable incruſtation, that was formed in the ſpace of three years only, within a ſquare wooden pipe, in a Coal Mine in Somerſetſhire. I gave a very particu-

(c) See the figure marked G 41.

lar account of this production in a paper laid before the Society in the year 1773[d], and therefore ſhall ſay nothing of it here but what immediately relates to the preſent purpoſe. The pipe was forty-two feet in length, and the hollow part of it was ſeven inches and an half wide, by four inches and an half; and this whole cavity was ſo filled with the incruſted matter (which was hard enough to take an exceeding fine poliſh, like the moſt beautiful marble) that at laſt there was left a water way, which, nearly uniformly throughout the whole length of the pipe, was only about three inches and an half by one inch; and thus there was formed, within the firſt wooden pipe, a ſecond pipe of this incruſtration, the thickneſs of the ſides of which was about one inch and an half. On cutting a tranſverſe ſection of this pipe there appeared a number of uniform lines, forming almoſt regular ſimilar parallelograms, one within another, like the coats of an onion, and plainly denoting the gradual and regular progreſs of the formation of the whole incruſtation. But the circumſtance moſt remarkable, and that is more immediately applicable to the preſent purpoſe, is, that where there was, by accident, the point of a nail projecting through the ſide of the wooden pipe, it ſo accelerated the progreſs of the incruſtation, that, adjoining thereto, the ſimilar ſides of the firſt and outward

(d) Phil. Tranſ. vol. LXIII. p. 241.

parallelograms next the wooden pipe (inſtead of continuing as ſtraight lines) formed in that place very bold ſemi-circular curves, or protuberances, one beyond another, projecting from the wooden pipe inwards; and this curvilinear projection was uniformly continued throughout all the ſimilar parallelograms quite to the inward cavity of the pipe formed by the incruſtation, and there at laſt occaſioned a projecting gibboſity, of a conſiderable extent every way, from the point of the nail (e).

Having mentioned theſe remarkable facts to my very learned and ingenious friend Dr. FOTHERGILL, I had the pleaſure to find they ſtruck him much in the ſame light in which they had appeared to me; and that he, moreover, formed the ſame concluſion concerning the ſpecimen now laid before the Society that you had alſo formed and mentioned in the note you favoured me with when you ſent the ſpecimen to my houſe; namely, that the concretion was effected by the ſolution of the adjoining iron ring.

Dr. FOTHERGILL alſo (who had communicated ſome very original conjectures upon this ſubject to the Society many years (f) ago) informed me of ſome further

(e) There is another fragment of the incruſtation formed within this pipe, with a tranſverſe ſection thereof poliſhed, in the Muſeum of the Royal Society; but that with the point of the nail, which is here alluded to, is ſtill in my poſſeſſion.

(f) In a paper on the Origin of Amber, read in the year 1743.

curious facts, which he permits me now to mention in this paper.

On paſſing through the ſtreets of London in his walks, before the ſign-irons were taken down, he perceived, that on the broad ſtone pavements, whenever he came juſt under any ſign-irons, his cane gave a different ſound, and occaſioned a different kind of reſiſtance to the hand, from what it did elſewhere; and attending more particularly to this circumſtance, he found, that every where, under the drip of thoſe irons, the ſtones had acquired a greater degree of ſolidity, and a wonderful hardneſs, ſo as to reſiſt any ordinary tool, and gave, when ſtruck upon, a metallic ſound: and this fact, by repeated obſervations, he was at length moſt thoroughly convinced of.

Taking the hint, therefore, from hence, he thought fit to make ſeveral experiments; and, amongſt the reſt, placed two pieces of Portland ſtone in the ſame aſpect and ſituation in every reſpect, but waſhed the one frequently with water impregnated with ruſty iron, and left the other untouched: and in a very few years he found the former had acquired a very ſenſible degree of that hardneſs before deſcribed, and on being ſtruck gave the metallic ſound; whilſt the other remained in its original ſtate, and ſubject to the decays occaſioned by the changes

of

of the weather, which we find in many inſtances make a moſt rapid progreſs.

He alſo mentioned to me a very curious circumſtance of his having found on the ſea-coaſt near Scarborough, many years ago, part of an horſe-ſhoe incruſted with ſea ſand, which was ſo concreted as to have acquired the hardneſs of common grit ſtone, and retained the colour of the ſand, with very little tincture of the iron ochre: and by the part which was left free from the incruſtation it appeared moſt probable, that the horſe-ſhoe had not been buried there many years, but had very recently acquired this incruſtation upon that part only that was moſt expoſed to the waſhing of the ſea water.

Now, all theſe facts put together ſcarce leave any doubt but that iron, and ſolutions of iron, do greatly promote and haſten the progreſs of all kinds of petrifaction; and therefore, to purſue Lord BACON's rule of induction, deducing truth from a variety of facts and experiments, all manifeſtly and uniformly leading us to the ſame concluſion, we may fairly infer, that whereas iron is of ſuch manifeſt uſe in the progreſs of vegetation, that plants are indebted for their green colour(*g*), and for

(*g*) There are ſome exceeding curious experiments and obſervations of Mr. BELAVAL's, tending to illuſtrate this fact, in the Phil. Tranſ. vol. LV. p. 36, 37.

many of their valuable qualities, to its being intimately mixed in their ſubſtance; and as it is moreover obviouſly uſeful, ſome way or other, in the animal ſyſtem, and may be extracted by the magnet from the aſhes of animal ſubſtances; ſo it is no leſs uſeful in the conſolidation of ſtones and marble in the foſſil world.

Mr. PRYCE, in a very uſeful and curious treatiſe of Mineralogy (b), has moreover lately ſhewn it to be equally uſeful in the mineral world, by forming a proper *nidus* for the aſſemblage of the moſt valuable metals, and attracting and uniting them thereby. This metal, therefore, ſeems to be almoſt univerſally one of the greateſt bands that unites the ſeveral parts of matter, and one of the moſt uſeful and important of ſubſtances in the world.

It is not for us to preſume to comprehend any thing about the original formation of bodies. Such diſquiſitions are far out of the reach of our faculties; nor do I at all pretend to enter into them: but we are permitted to behold and conſider the works of the Almighty, and may become wiſer and reap profit from the contemplation of them, and may perceive in what manner many new combinations of matter are continually effected.

And as we manifeſtly perceive plants to grow daily for the neceſſary ſupplies of life, without knowing how

(b) Mineralogia Cornubienſis, p. 6. 11. 67.

they

they grow; but yet are convinced they are nouriſhed by means of the ſalts and particles of matter conveyed to them by water and vapour, and that iron is a neceſſary ingredient in their compoſition; ſo I am perſuaded we ſhall, at length, perceive (notwithſtanding the general opinion to the contrary) that even ſtones and marbles are ſtill continually forming in the earth for the ſervices of human life, and to ſupply the continual waſte and decay that there is of thoſe ſubſtances; and that the conſolidation of them is effected by means of water and vapour likewiſe (of which I am able to produce very many and convincing proofs); and that iron, which is what alone I wiſh now to make apparent, is unqueſtionably a principal means of effecting the induration of many of thoſe bodies.

But I would not willingly trouble the Society with this paper as a matter of mere ſpeculation. I would wiſh that ſome hint, which might be more immediately uſeful, ſhould, if poſſible, be derived therefrom; and ſuch has been ſuggeſted to me by Dr. FOTHERGILL.

If iron and the ſolutions of iron do thus contribute to the induration of bodies, ſuch ſolutions muſt probably have that tendency in every ſtage of thoſe bodies' exiſtence; and therefore it ſeems likely, that the fine ornamental carvings in Portland, or other ſtone, might be much

much hardened, and preſerved for a much longer time than has been uſual, from the injuries of the weather, by being waſhed and bruſhed over by water, in which is infuſed a ſolution of iron. And perhaps even the ſofter kinds of ſtones might have been preſerved by this means; and the venerable remains of that fine pile of building HENRY the VIIth's chapel, might have been ſaved from the deſtruction with which we now ſee it ready to be overwhelmed.

It is very probable, moreover, that common ſea ſand, with a very ſmall admixture of a ſolution of iron, may at length, without any great expence, be converted into a moſt uſeful ſpecies of ſtone, and be applied to the purpoſe of covering the fronts of houſes even more durably, and in as beautiful a manner as ſome of the late invented ſtuccos; and even thoſe ſtuccos may be improved by means of the ſame mixture.

It muſt be left to future experiments to aſcertain what proportions of the ſolutions of iron are beſt to be made uſe of; and in what manner the ſolution may beſt be obtained for this purpoſe; whether by a vitriolic acid; or merely by laying ruſty iron for ſome time in water (i). But one caution ſhould be obſerved; namely, that if too

(i) It is not perhaps poſſible to contrive a leſs ſaturated tincture of iron than the ruſt diſſolved in water.

great

great a proportion of vitriolic acid be left in the mixture, it may do more miſchief than the iron can do good. With this caution it were perhaps much to be wiſhed, that experiments[b] ſhould be made, and attended to, for a long courſe of years; for without ſuch continued and repeated trials, it will be impoſſible to determine in what manner the application may be made with moſt advantage.

I have only therefore to add, that what has been ſaid may perhaps receive ſome further confirmation, from conſidering that the chief conſtituent parts of all cements for ſtone are always lime and iron[i]; and that any experiments made in conſequence of theſe obſervations will be likely to ſucceed more rapidly in warm climates than in colder ones.

Whatever there is of inaccuracy in this ſhort paper will I am perſuaded meet with indulgence both from you and from the Society, whilſt whatever truth is brought to light thereby will be received and adopted. I therefore venture to deliver it into your hands without heſitation. I am, &c.

(*b*) The ages of modern buildings are eaſily known, and there are none but what have iron rails or bars about them expoſed to the weather. If the rain drops from them on Portland or any gritty ſtone, it becomes harder. The length of time ſuch ſtones have been ſubjected to this proceſs may eaſily be known, and the effects produced in them may be verified by repeated compariſons of different fragments.

(*i*) See CROUSTEDT's Mineralogy, p. 45.

I have added a few rough ſketches to explain what has been ſaid in this letter.

FIG I. Repreſents the maſs of concreted ſand and rope from the coaſt of Lothian.

AB ſhews where there is one impreſſion of a part of the iron ring.

CD ſhews were there is alſo another impreſſion of the ring; and

EF ſhews where there alſo remain ſome impreſſions of bits of untwiſted rope, ſo that this whole maſs ſeems to have been formed within the circumference of the ring.

FIG. II. Repreſents a tranſverſe ſection of the petrefaction within the wooden pipe, from the coal mine in Somerſetſhire; and

G ſhews the place of the point of the nail, and the regular curvilinear projection of the petrefaction around it, regularly throughout the whole progreſs.

FIG. III. Is a ſketch of the gun, ſhewing the parts to which the incruſtation adhered.

Fig: I.

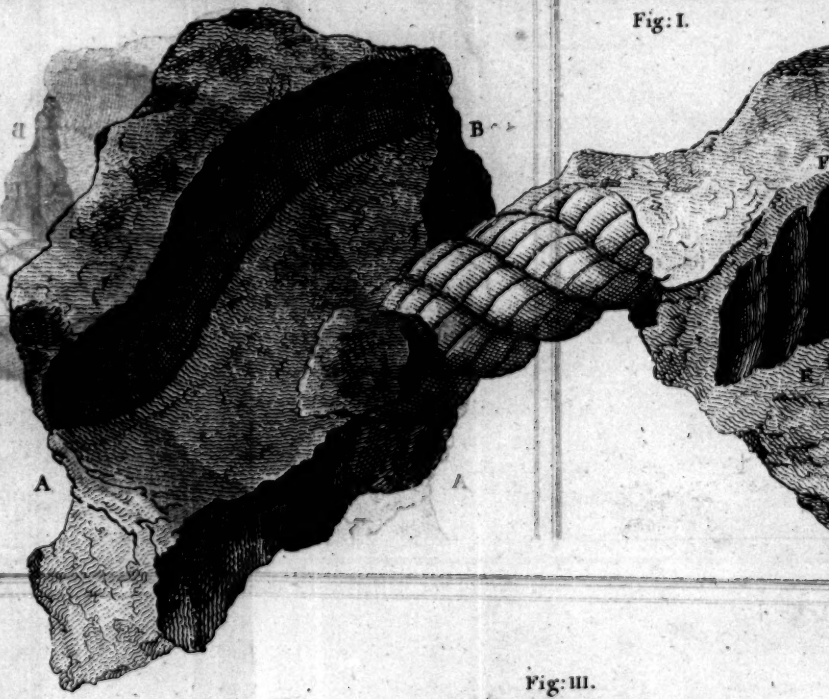
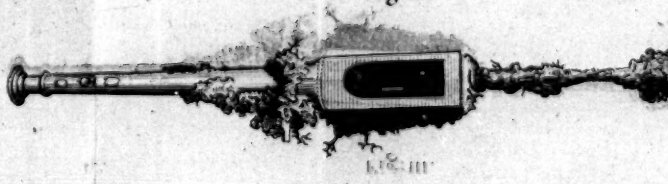


Fig: III.



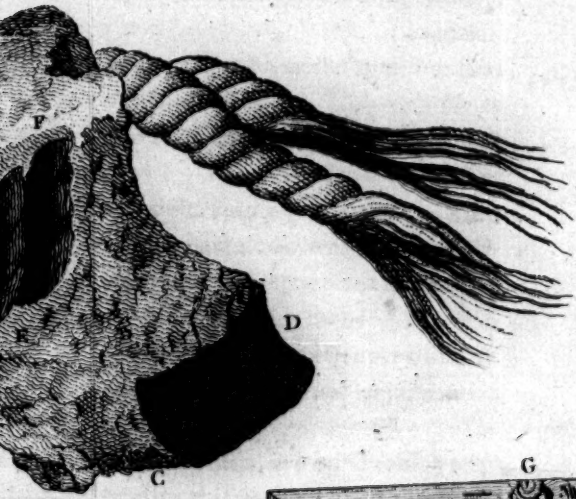
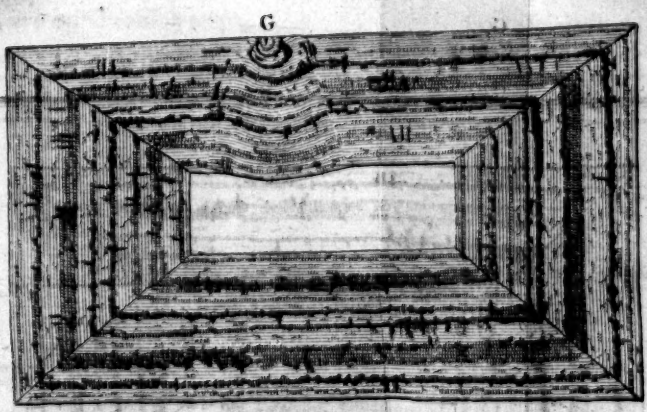


Fig. II.



V. *Account of Dr.* Knight's *Method of making artificial Loadſtones. By Mr.* Benjamin Wilſon, *F. R. S.*

TO JOSEPH BANKS, ESQ. P. R. S.

SIR,

Read Dec. 17, 1778. THE method of making artificial loadſtones, as it was diſcovered and practiced by the late Dr. GOWIN KNIGHT, being unknown to the public; and I myſelf having been frequently preſent when the doctor was employed in the moſt material ſteps of that curious proceſs, I thought a communication thereof would be agreeable to you and the philoſophic world.

The method was this: having provided himſelf with a large quantity of clean filings of iron, he put them into a large tub that was more than one-third filled with clean water: he then, with great labour, worked the tub to and fro for many hours together, that the friction between the grains of iron by this treatment might break off ſuch

ſmaller parts as would remain ſuſpended in the water for a time. The obtaining of thoſe very ſmall particles in ſufficient quantity ſeemed to him to be one of the principal *deſiderata* in the experiment.

The water being by this treatment rendered very muddy, he poured the ſame into a clean earthen veſſel, leaving the filings behind; and when the water had ſtood long enough to become clear, he poured it out carefully, without diſturbing ſuch of the iron ſediment as ſtill remained, which now appeared reduced almoſt to impalpable powder. This powder was afterwards removed into another veſſel, in order to dry it; but as he had not obtained a proper quantity thereof, by this one ſtep he was obliged to repeat the proceſs many times.

Having at laſt procured enough of this very fine powder, the next thing to be done was to make a paſte of it, and that with ſome vehicle which would contain a conſiderable quantity of the phlogiſtic principle; for this purpoſe he had recourſe to linſeed oil in preference to all other fluids.

With theſe two ingredients only he made a ſtiff paſte, and took particular care to knead it well before he moulded it into convenient ſhapes. Sometimes, whilſt the paſte continued in its ſoft ſtate, he would put the impreſſion

impreſſion of a ſeal upon the ſeveral pieces; one of which is in the Britiſh Muſeum.

This paſte was then put upon wood, and ſometimes on tiles, in order to bake or dry it before a moderate fire, at a foot diſtance or thereabouts.

The doctor found, that a moderate fire was moſt proper, becauſe a greater degree of heat made the compoſition frequently crack in many places.

The time required for the baking or drying of this paſte was generally five or ſix hours before it attained a ſufficient degree of hardneſs. When that was done, and the ſeveral baked pieces were become cold, he gave them their magnetic virtue in any direction he pleaſed, by placing them between the extreme ends of his large magazine of artificial magnets for a few ſeconds or more, as he ſaw occaſion.

By this method the virtue they acquired was ſuch, that when any one of thoſe pieces was held between two of his beſt ten guinea bars, with its poles purpoſely inverted, it immediately of itſelf turned about to recover its natural direction, which the force of thoſe very powerful bars was not ſufficient to counteract.

I am, &c.

VI. *Account of an extraordinary Dropſical Caſe. By Mr.* John Latham, *in a Letter to Mr.* Warner, *F. R. S.*

TO MR. WARNER.

Dartford,
SIR, October 28, 1778.

Read Dec. 17, 1778. WHEN I laſt had the pleaſure of ſeeing you, it was your opinion, that the Royal Society would receive ſome ſatisfaction in my giving ſome account of the caſe of Miſs A. M. who died lately of a dropſy under my care.

This patient was of a florid, lively conſtitution, but from a child was ſubject to a violent eruption, which came generally on a ſudden, covering the whole neck, breaſt, and often great part of the face; and after remaining a week or two abated in violence, and went off by degrees. The intervals were uncertain, but for the moſt part in ſpring and in autumn ſhe was more apt to have it, though frequently three or four times in the year. Various methods were tried to eradicate this com-

plaint without effect; nor did the appearance of the menſes, as we had ſome reaſon to hope, in the leaſt turn out in her favour. It will be needleſs to relate here the various medicines which had been given her with little or no ſucceſs, except that the moſt relief ſhe found was from the uſe of ſalt water, which was thought to make the intervals the longer in two or three inſtances, as well as the appearance of the eruption milder. Things continued thus till the autumn 1773, when the menſes became obſtructed, continuing ſo for ſome months, but appeared once more very plentifully; after which they never returned, neither did the eruption, except in the moſt trifling manner. About Chriſtmas 1773 ſhe complained of a weight in the abdomen, and fulneſs of the ſtomach; which ſymptoms were relieved by ſome gentle opening medicines. She then went on a viſit to ſome friends at a diſtance, after which I ſaw her no more for two months. I learned, that during that time the complaints had returned more violent, for which ſhe conſulted a phyſician on the ſpot, but without the relief ſhe found at firſt; for the abdomen began to increaſe in ſize every day, and became painful, the urine high-coloured, and in ſmall quantity, with thirſt, and every other ſymptom of an approaching dropſy.

In

In a narrative of this kind it may be expected, that a detail of the medicines ſhe took during her illneſs might be noted; but as I chiefly acted in my ſurgical capacity, and as ſhe was after this time, till the firſt operation, for the moſt part in London, under the care of phyſicians of the firſt eminence, it is out of my power to give ſuch an account; ſuffice it then to ſay, that ſhe was obliged to ſubmit to the operation of the *paracenteſis* the 27th of June, 1774. The quantity I then took off was only twelve pints, ſomewhat fœtid, but not very dark coloured, nor was it ever after the leaſt offenſive. The operation was repeated in ſix weeks, when twenty-nine pints were taken off; after that time once in four weeks to the end of the year. During the whole of the year 1775 I tapped her once in a fortnight more or leſs; and in the year 1776 ſhe for the moſt part underwent the operation every eight or nine days, the intervals gradually ſhortening, till by the end of the year ſhe could go no longer than a week between, which continued to the day of her death, which happened May 14, 1778, being then not quite twenty-three years of age. About a week before that time, ſhe was troubled with inceſſant vomitings, which nothing would relieve; but was better a few hours before her death, and went off pretty eaſy.

I have good reason to suppose the complaint originated from a disease of the left ovary, for after the first tapping I felt a substance of the size of a cricket ball; and, as the operations went on, this became more and more manifest, increasing so much as at last to occupy the whole space of the *abdomen* forward, being of a very irregular form, and I am clear of many pounds weight, for she appeared, even after the water had been drawn off, as large as a woman in the last month of pregnancy. It would have added greatly to my satisfaction to have been able to clear up this point in every particular, by opening her after death; but I had the extreme mortification of being denied this necessary circumstance, notwithstanding my most earnest solicitations.

I must, therefore, content myself with giving this bare recital of facts as above, which will serve to record to futurity, a case which I believe has not its equal in regard to the number of operations. What is remarkable here is, that this young lady had a good appetite for the most part, and was very chearful; and, except a day before and after each operation, used to visit her friends at several miles distance as she would have done in health, and till within the last two or three months could walk a mile or two with tolerable ease.

As to the quantity of water taken off, I find it to amount, upon the neareſt calculation, to twenty-four pints at each operation; for though the firſt time produced only twelve pints, and in ſeveral of the latter operations the quantity fell ſhort of twenty-four pints, yet I may venture to ſtate it at leaſt at twenty-four pints or three gallons on an average, as in many of the operations I took off from twenty-eight to thirty pints. The number of times I tapped her was in all 155, which brings out in the whole 3720 pints, being 465 gallons, not far ſhort of ſeven hogſheads and an half. As to the authenticity of the whole, your connections with the family, and frequent opportunities of ſeeing this young lady during her illneſs, will put it beyond a doubt. I have therefore no more to add, than my wiſh that the caſe may prove acceptable to the Society.

I am, &c.

VII. *Problems concerning Interpolations.* *By* Edward Waring, *M. D. F. R. S. and of the Inſtitute of* Bononia, Lucaſian *Profeſſor of Mathematics in the Univerſity of* Cambridge.

Read Jan. 9, 1779.

MR. BRIGGS was the firſt perſon, I believe, that invented a method of differences for interpolating logarithms at ſmall intervals from each other: his principles were followed by REGINALD and MOUTON in France. Sir ISAAC NEWTON, from the ſame principles, diſcovered a general and elegant ſolution of the abovementioned problem: perhaps a ſtill more elegant one on ſome accounts has been ſince diſcovered by Meſſ. NICHOLE and STIRLING. In the following theorems the ſame problem is reſolved and rendered ſomewhat more general, without having any recourſe to finding the ſucceſſive differences.

THEOREM I.

Aſſume an equation $a+bx+cx^2+dx^3 \ldots . x^{n-1}=y$, in which the co-efficients a, b, c, d, e, &c. are invariable;

let α, β, γ, δ, ε, &c. denote n values of the unknown quantity x, whose correspondent values of y let be represented by s^{α}, s^{β}, s^{γ}, s^{δ}, s^{ε}, &c. Then, will the equation $a+bx+cx^2+dx^3+ex^4 \ldots x^{n-1}=y=$

$$\frac{\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\alpha-\beta}\times\overline{\alpha-\gamma}\times\overline{\alpha-\delta}\times\overline{\alpha-\varepsilon}\times\text{&c.}}\times s^{\alpha}+\frac{\overline{x-\alpha}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\beta-\alpha}\times\overline{\beta-\gamma}\times\overline{\beta-\delta}\times\overline{\beta-\varepsilon}\times\text{&c.}}\times s^{\beta}$$

$$+\frac{\overline{x-\alpha}\times\overline{x-\beta}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\gamma-\alpha}\times\overline{\gamma-\beta}\times\overline{\gamma-\delta}\times\overline{\gamma-\varepsilon}\times\text{&c.}}\times s^{\gamma}+\frac{\overline{x-\alpha}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\delta-\alpha}\times\overline{\delta-\beta}\times\overline{\delta-\gamma}\times\overline{\delta-\varepsilon}\times\text{&c.}}\times s^{\delta}$$

$$+\frac{\overline{x-\alpha}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\text{&c.}}{\overline{\varepsilon-\alpha}\times\overline{\varepsilon-\beta}\times\overline{\varepsilon-\gamma}\times\overline{\varepsilon-\delta}\times\text{&c.}}\times s^{\varepsilon}+\text{&c.}$$

DEMONSTRATION.

Write α for x in the equation $y=$

$$\frac{\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\alpha-\beta}\times\overline{\alpha-\gamma}\times\overline{\alpha-\delta}\times\overline{\alpha-\varepsilon}\times\text{&c.}}\times s^{\alpha}+\frac{\overline{x-\alpha}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\beta-\alpha}\times\overline{\beta-\gamma}\times\overline{\beta-\delta}\times\overline{\beta-\varepsilon}\times\text{&c.}}\times s^{\beta}+$$

&c.; and all the terms but the first in the resulting equation will vanish, for each of them contains in its numerator a factor $x-\alpha=\alpha-\alpha=0$; and the equation will become $y=\frac{\overline{\alpha-\beta}\times\overline{\alpha-\gamma}\times\overline{\alpha-\delta}\times\overline{\alpha-\varepsilon}\times\text{&c.}}{\overline{\alpha-\beta}\times\overline{\alpha-\gamma}\times\overline{\alpha-\delta}\times\overline{\alpha-\varepsilon}\times\text{&c.}}\times s^{\alpha}=s^{\alpha}$. In the same manner, by writing β, γ, δ, ε, &c. successively for x in the given equation it may be proved, that when x is equal to β, γ, δ, ε, &c. then will y become respectively s^{β}, s^{γ}, s^{δ}, s^{ε}, which was to be demonstrated.

2. Assume $y=ax^r+bx^{r+s}+cx^{r+2s}+dx^{r+3s}\ldots x^{r+\overline{n-1}s}$; and when x becomes α, β, γ, δ, ε, &c. let y become respectively

ſpectively s^{α}, s^{β}, s^{γ}, s^{δ}, s^{ι}, &c.; then will $y =$

$$\frac{x' \times \overline{x'-\beta'} \times \overline{x'-\gamma'} \times \overline{x'-\delta'} \times \overline{x'-\iota'} \times \&c.}{\alpha' \times \overline{\alpha'-\beta'} \times \overline{\alpha'-\gamma'} \times \overline{\alpha'-\delta'} \times \overline{\alpha'-\iota'} \times \&c.} \times s^{\alpha}$$

$$+ \frac{x' \times \overline{x'-\alpha'} \times \overline{x'-\gamma'} \times \overline{x'-\delta'} \times \overline{x'-\iota'} \times \&c.}{\beta' \times \overline{\beta'-\alpha'} \times \overline{\beta'-\gamma'} \times \overline{\beta'-\delta'} \times \overline{\beta'-\iota'} \times \&c.} \times s^{\beta}$$

$$+ \frac{x' \times \overline{x'-\alpha'} \times \overline{x'-\beta'} \times \overline{x'-\delta'} \times \overline{x'-\iota'} \times \&c.}{\gamma' \times \overline{\gamma'-\alpha'} \times \overline{\gamma'-\beta'} \times \overline{\gamma'-\delta'} \times \overline{\gamma'-\iota'} \times \&c.} \times s^{\gamma} + \&c.$$

This may be demonſtrated in the ſame manner as the preceding theorem, by writing α, β, γ, δ, ε, &c. ſucceſſively for x.

PROBLEM.

Let there be n values $\alpha, \beta, \gamma, \delta, \varepsilon$, &c. of the quantity x, to which the n values s^{α}, s^{β}, s^{γ}, s^{δ}, s^{ι}, &c. of the quantity y correſpond; ſuppoſe theſe quantities to be found by any function X of the quantity x; let π, ϱ, σ, τ, &c. be values of the quantities x, to which s^{π}, s^{ϱ}, s^{σ}, s^{τ}, &c. values of the quantity y correſpond: for x ſubſtitute its abovementioned values π, ϱ, σ, τ, &c. in the function X, and let the quantities reſulting be s^{π}, s^{ϱ}, s^{σ}, s^{τ}, &c. not equal to the preceding s^{π}, s^{ϱ}, s^{σ}, s^{τ}, &c. reſpectively; to find a quantity which added to the function X ſhall not only give the true values of the quantity y correſponding to the values α, β, γ, δ, ε, &c. of the quantity x, but alſo

cor-

corresponding to the values π, ϱ, σ, τ, &c. of the above-mentioned quantity x.

Assume $s^{\pi}-s^{\varrho}=T^{\pi}$, $s^{\varrho}-s^{\sigma}=T^{\varrho}$, $s^{\sigma}-s^{\tau}=T^{\sigma}$, $s^{\tau}-s^{\upsilon}=T^{\tau}$, &c.; then the errors of the function X will be respectively T^{π}, T^{ϱ}, T^{σ}, T^{τ}, &c.; and the correcting quantity sought may be

$$\frac{\overline{x-\alpha}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\pi-\alpha}\times\overline{\pi-\beta}\times\overline{\pi-\gamma}\times\overline{\pi-\delta}\times\overline{\pi-\varepsilon}\times\text{&c.}}\times\frac{\overline{x-\varrho}\times\overline{x-\sigma}\times\overline{x-\tau}\times\text{&c.}}{\overline{\pi-\varrho}\times\overline{\pi-\sigma}\times\overline{\pi-\tau}\times\text{&c.}}\times T^{\pi}$$

$$+\frac{\overline{x-\alpha}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\varrho-\alpha}\times\overline{\varrho-\beta}\times\overline{\varrho-\gamma}\times\overline{\varrho-\delta}\times\overline{\varrho-\varepsilon}\times\text{&c.}}\times\frac{\overline{x-\pi}\times\overline{x-\sigma}\times\overline{x-\tau}\times\text{&c.}}{\overline{\varrho-\pi}\times\overline{\varrho-\sigma}\times\overline{\varrho-\tau}\times\text{&c.}}\times T^{\varrho}$$

$$+\frac{\overline{x-\alpha}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\sigma-\alpha}\times\overline{\sigma-\beta}\times\overline{\sigma-\gamma}\times\overline{\sigma-\delta}\times\overline{\sigma-\varepsilon}\times\text{&c.}}\times\frac{\overline{x-\pi}\times\overline{x-\varrho}\times\overline{x-\tau}\times\text{&c.}}{\overline{\sigma-\pi}\times\overline{\sigma-\varrho}\times\overline{\sigma-\tau}\times\text{&c.}}\times T^{\sigma}$$

$$+\frac{\overline{x-\alpha}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times\text{&c.}}{\overline{\tau-\alpha}\times\overline{\tau-\beta}\times\overline{\tau-\gamma}\times\overline{\tau-\delta}\times\overline{\tau-\varepsilon}\times\text{&c.}}\times\frac{\overline{x-\pi}\times\overline{x-\varrho}\times\overline{x-\sigma}\times\text{&c.}}{\overline{\tau-\pi}\times\overline{\tau-\varrho}\times\overline{\tau-\sigma}\times\text{&c.}}\times T^{\tau}$$

+ &c.

Aliter.

Let $\overline{x-\alpha}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\varepsilon}\times$ &c. $\times\overline{x-\pi}\times\overline{x-\varrho}\times\overline{x-\sigma}\times\overline{x-\tau}\times$ &c. $=N$; $\overline{\pi-\alpha}\times\overline{\pi-\beta}\times\overline{\pi-\gamma}\times\overline{\pi-\delta}\times\overline{\pi-\varepsilon}\times$ &c. $\times\overline{\pi-\varrho}\times\overline{\pi-\sigma}\times\overline{\pi-\tau}\times$ &c. $=\Pi$; $\overline{\varrho-\alpha}\times\overline{\varrho-\beta}\times\overline{\varrho-\gamma}\times\overline{\varrho-\delta}\times\overline{\varrho-\varepsilon}\times$ &c. $\times\overline{\varrho-\pi}\times\overline{\varrho-\sigma}\times\overline{\varrho-\tau}\times$ &c. $=P$; $\overline{\sigma-\alpha}\times\overline{\sigma-\beta}\times\overline{\sigma-\gamma}\times\overline{\sigma-\delta}\times\overline{\sigma-\varepsilon}\times$ &c. $\times\overline{\sigma-\pi}\times\overline{\sigma-\varrho}\times\overline{\sigma-\tau}\times$ &c. $=\Sigma$; $\overline{\tau-\alpha}\times\overline{\tau-\beta}\times\overline{\tau-\gamma}\times\overline{\tau-\delta}\times\overline{\tau-\varepsilon}\times$ &c. $\times\overline{\tau-\pi}\times\overline{\tau-\varrho}\times\overline{\tau-\sigma}\times$ &c. $=T$, &c.; then may the correcting quantity sought be $N\left(\frac{T^{\pi}}{\Pi\times\overline{x-\pi}}+\frac{T^{\varrho}}{P\times\overline{x-\varrho}}\right.$

$$+\frac{T^{\sigma}}{\Sigma\times\overline{x-\sigma}}+\frac{T^{\tau}}{T\times\overline{x-\tau}}+\text{&c.}\Big).$$

This

This problem may be demonſtrated in the ſame manner as the preceding theorems, by writing for x in the correcting quantity ſucceſſively its values π, ϱ, σ, τ, &c.

2. For the correcting quantity ſought may be aſſumed the quantity $\frac{x'-\alpha' \times x'-\beta' \times x'-\gamma' \times x'-\delta' \times \&c. \times x'' \times x'-\varepsilon' \times x'-\sigma'}{\pi'-\alpha' \times \pi'-\beta' \times \pi'-\gamma' \times \pi'-\delta' \times \&c. \times \pi'' \times \pi'-\varepsilon' \times \pi'-\sigma'} \times \frac{x'-\tau' \times \&c.}{\pi'-\tau' \times \&c.} \times T^{\pi} + \frac{x'-\alpha' \times x'-\beta' \times x'-\gamma' \times x'-\delta' \times \&c. \times x'' \times x'-\sigma'}{\varrho'-\alpha' \times \varrho'-\beta' \times \varrho'-\gamma' \times \varrho'-\delta' \times \&c. \times \varrho'' \times \varrho'-\sigma'} \times \frac{x'-\sigma' \times x'-\tau' \times \&c.}{\varrho'-\sigma' \times \varrho'-\tau' \times \&c.} \times T^{\varrho} + \&c.$

3. In general, let z be any quantity which is $=o$, when x becomes either α, β, γ, δ, ε, &c.: let z become ſucceſſively A, B, C, D, &c. when x becomes π, ϱ, σ, τ, &c. reſpectively. When x either $=\varrho$, σ, τ, &c. let $\Pi=o$; but if $x=\pi$, let $\Pi=p$: in the ſame manner when x either $=\pi$, σ, τ, &c. let $P=o$; but when $x=\varrho$ let $P=r$: and ſimilarly, let $\Sigma=o$ when x is either π, ϱ, τ, &c.; but when $x=\sigma$ let $\Sigma=s$: and likewiſe, when x is either π, ϱ, σ, &c. let $T=o$; but when $x=\tau$ let $T=t$: &c. then for the correcting quantity ſought may be aſſumed $\frac{z}{A} \times \frac{\Pi}{p} \times T^{\pi} + \frac{z}{B} \times \frac{P}{r} \times T^{\varrho} + \frac{z}{C} \times \frac{\Sigma}{s} \times T^{\sigma} + \frac{z}{D} \times \frac{T}{t} \times T^{\tau} + \&c.$

THE-

THEOREM.

Aſſume (n) quantities $\alpha, \beta, \gamma, \delta, \varepsilon$, &c. then will the ſum of all the (n) quantities of the following kind

$$\frac{\alpha^m}{\alpha-\beta\times\alpha-\gamma\times\alpha-\delta\times\alpha-\iota\times \&c.} + \frac{\beta^m}{\beta-\alpha\times\beta-\gamma\times\beta-\delta\times\beta-\iota\times \&c.}$$

$$+ \frac{\gamma^m}{\gamma-\alpha\times\gamma-\beta\times\gamma-\delta\times\gamma-\iota\times \&c.} + \frac{\delta^m}{\delta-\alpha\times\delta-\beta\times\delta-\gamma\times\delta-\iota\times \&c.}$$

$$+ \frac{\iota^m}{\iota-\alpha\times\iota-\beta\times\iota-\gamma\times\iota-\delta\times \&c.} + \&c. = o,$$

if m be any whole number leſs than $n-1$; but if $m=n-1$, then will the above mentioned ſum $=1$. In general, the ſum of the n terms

$$\frac{\alpha^m(\beta\gamma\delta\,\&c. + \beta\gamma\iota\,\&c. + \beta\delta\iota + \gamma\delta\iota\,\&c. + \&c.)}{\alpha-\beta\times\alpha-\gamma\times\alpha-\delta\times\alpha-\iota\times \&c.} +$$

$$\frac{\beta^m(\alpha\gamma\delta\&c. + \alpha\gamma\iota\&c. + \alpha\delta\iota\,\&c. + \gamma\delta\iota\&c. + \&c.)}{\beta-\alpha\times\beta-\gamma\times\beta-\delta\times\beta-\iota\times \&c.} +$$

$$\frac{\gamma^m(\alpha\beta\delta\&c. + \alpha\beta\iota\,\&c. + \alpha\delta\iota\,\&c. + \beta\delta\iota\,\&c. + \&c.)}{\gamma-\alpha\times\gamma-\beta\times\gamma-\delta\times\gamma-\iota\,\&c.} +$$

$$\frac{\delta^m(\alpha\beta\gamma\,\&c. + \alpha\beta\iota\,\&c. + \alpha\gamma\iota\,\&c. + \&c.)}{\delta-\alpha\times\delta-\beta\times\delta-\gamma\times\delta-\iota\times \&c.} +$$

$$\frac{\iota^m(\alpha\beta\gamma\,\&c. + \alpha\beta\delta\&c. + \alpha\gamma\delta\,\&c. + \beta\gamma\delta\&c. + \&c.)}{\iota-\alpha\times\iota-\beta\times\iota-\gamma\times\iota-\delta\times \&c.} + \&c. = \rho,$$

if m be leſs than n, and $m+r$ not equal to $n-1$, where r is equal to the number of letters contained in each of the contents above mentioned $\beta\gamma\delta$, &c. $\beta\gamma\varepsilon$, &c. $\beta\delta\varepsilon$, &c. $\gamma\delta\varepsilon$, &c. &c. &c. reſpectively: but if $m+r=n-1$, then will the above mentioned ſum $=\pm 1$; it will be $+1$ if r be an even number, otherwiſe -1.

DEMONSTRATION.

Suppose $a+b\alpha+c\alpha^2+d\alpha^3+e\alpha^4+$ &c. $=s^\alpha$,

$a+b\beta+c\beta^2+d\beta^3+e\beta^4+$ &c. $=s^\beta$,

$a+b\gamma+c\gamma^2+d\gamma^3+e\gamma^4+$ &c. $=s^\gamma$,

$a+b\delta+c\delta^2+d\delta^3+e\delta^4+$ &c. $=s^\delta$,

$a+b\varepsilon+c\varepsilon^2+d\varepsilon^3+e\varepsilon^4+$ &c. $=s^\varepsilon$, multiply these equations into A, B, C, D, E, &c. unknown coefficients to be investigated, and there result

$$A\times s^\alpha = Aa+Ab\alpha+Ac\alpha^2+Ad\alpha^3+Ae\alpha^4+\&c.$$

$$B\times s^\beta = Ba+Bb\beta+Bc\beta^2+Bd\beta^3+Be\beta^4+\&c.$$

$$C\times s^\gamma = Ca+Cb\gamma+Cc\gamma^2+Cd\gamma^3+Cd\gamma^4+\&c.$$

$$D\times s^\delta = Da+Db\delta+Dc\delta^2+Dd\delta^3+Dd\delta^4+\&c.$$

$$E\times s^\varepsilon = Ea+Eb\varepsilon+Ec\varepsilon^2+Ed\varepsilon^3+Ee\varepsilon^4+\&c.\ \&c.\ \&c.$$

Now suppose $As^\alpha+Bs^\beta+Cs^\gamma+Ds^\delta+Es^\varepsilon+$ &c. $=a+bx+cx^2+dx^3+ex^4+$ &c. and the correspondent parts respectively equal to each other; that is, $a(A+B+C+D+E+\&c.)=a$; $b(A\alpha+B\beta+C\gamma+D\delta+E\varepsilon+\&c.)=bx$; $A\alpha^2+B\beta^2+C\gamma^2+D\delta^2+E\varepsilon^2+\&c.=x^2$; $A\alpha^3+B\beta^3+C\gamma^3+D\delta^3+E\varepsilon^3+\&c.=x^3$; $A\alpha^4+B\beta^4+C\gamma^4+D\delta^4+E\varepsilon^4+\&c.=x^4$, &c. But it follows from Theorem I. that (if $As^\alpha+Bs^\beta+Cs^\gamma+Ds^\delta+Es^\varepsilon+\&c. = a+bx+cx^2+dx^3+ex^4+\&c.$) $A=\frac{x-\beta\times x-\gamma\times x-\delta\times x-\varepsilon\times\&c.}{\alpha-\beta\times\alpha-\gamma\times\alpha-\delta\times\alpha-\varepsilon\times\&c.}$,

$$B=\frac{\overline{x-a}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\beta-a}\times\overline{\beta-\gamma}\times\overline{\beta-\delta}\times\overline{\beta-\iota}\times\&c.},\quad C=\frac{\overline{x-a}\times\overline{x-\beta}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c}{\overline{\gamma-a}\times\overline{\gamma-\beta}\times\overline{\gamma-\delta}\times\overline{\gamma-\iota}\times\&c.},$$

$$D=\frac{\overline{x-a}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\iota}\times\&c.}{\overline{\delta-a}\times\overline{\delta-\beta}\times\overline{\delta-\gamma}\times\overline{\delta-\iota}\times\&c.},\quad E=\frac{\overline{x-a}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\&c.}{\overline{\iota-a}\times\overline{\iota-\beta}\times\overline{\iota-\gamma}\times\overline{\iota-\delta}\times\&c.},$$

&c.: fubſtitute theſe values for A, B, C, D, E, &c. reſpectively in the preceding equations ($A+B+C+D+E+\&c.=1$, $A\alpha+B\beta+C\gamma+D\delta+E\varepsilon+\&c.=x$, $A\alpha^2+B\beta^2+C\gamma^2+D\delta^2+E\varepsilon^2+\&c.=x^2$, $A\alpha^3+B\beta^3+C\gamma^3+D\delta^3+E\varepsilon^3+\&c.=x^3$, &c.) and there reſult the equations (1) $\frac{\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{a-\beta}\times\overline{a-\gamma}\times\overline{a-\delta}\times\overline{a-\iota}\times\&c.}+\frac{\overline{x-a}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\beta-a}\times\overline{\beta-\gamma}\times\overline{\beta-\delta}\times\overline{\beta-\iota}\times\&c.}+\frac{\overline{x-a}\times\overline{x-\beta}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\gamma-a}\times\overline{\gamma-\beta}\times\overline{\gamma-\delta}\times\overline{\gamma-\iota}\times\&c.}+\&c.=1$;

(2) $\alpha\times\frac{\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{a-\beta}\times\overline{a-\gamma}\times\overline{a-\delta}\times\overline{a-\iota}\times\&c.}+\beta\times\frac{\overline{x-a}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\beta-a}\times\overline{\beta-\gamma}\times\overline{\beta-\delta}\times\overline{\beta-\iota}\times\&c.}$

$$+\gamma\times\frac{\overline{x-a}\times\overline{x-\beta}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\gamma-a}\times\overline{\gamma-\beta}\times\overline{\gamma-\delta}\times\overline{\gamma-\iota}\times\&c.}+\&c.=x;$$

(3) $\alpha^2\times\frac{\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{a-\beta}\times\overline{a-\gamma}\times\overline{a-\delta}\times\overline{a-\iota}\times\&c.}+\beta^2\times\frac{\overline{x-a}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\beta-a}\times\overline{\beta-\gamma}\times\overline{\beta-\delta}\times\overline{\beta-\iota}\times\&c.}$

$+\gamma^2\times\frac{\overline{x-a}\times\overline{x-\beta}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\gamma-a}\times\overline{\gamma-\beta}\times\overline{\gamma-\delta}\times\overline{\gamma-\iota}\times\&c.}=x^2$; and in general,

$\alpha^m\times\frac{\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{a-\beta}\times\overline{a-\gamma}\times\overline{a-\delta}\times\overline{a-\iota}\times\&c.}+\beta^m\times\frac{\overline{x-a}\times\overline{x-\gamma}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\beta-a}\times\overline{\beta-\gamma}\times\overline{\beta-\delta}\times\overline{\beta-\iota}\times\&c.}$

$+\gamma^m\times\frac{\overline{x-a}\times\overline{x-\beta}\times\overline{x-\delta}\times\overline{x-\iota}\times\&c.}{\overline{\gamma-a}\times\overline{\gamma-\beta}\times\overline{\gamma-\delta}\times\overline{\gamma-\iota}\times\&c.}+\delta^m\times\frac{\overline{x-a}\times\overline{x-\beta}\times\overline{x-\gamma}\times\overline{x-\iota}\times\&c.}{\overline{\delta-a}\times\overline{\delta-\beta}\times\overline{\delta-\gamma}\times\overline{\delta-\iota}\times\&c.}$

$+\&c.=x^m$, whatever may be the values of the quantities x; $\alpha, \beta, \gamma, \delta, \varepsilon$, &c.: reduce all theſe fractions into terms, proceeding according to the dimenſions of the quantity x, and it is evident, that the ſum of all the fractions multiplied

tiplied into any dimenſion of x not equal to m will be $= 0$; but the ſum of all the fractions multiplied into x^m will be $= 1$: from this propoſition the theorem is eaſily deduced.

I have invented and demonſtrated from different principles to the preceding the firſt part of this theorem, a particular caſe of which was publiſhed by me many years ago.

From this theorem may eaſily be deduced ſeveral others of a ſimilar nature.

VIII. *Disquisitio de tempore Periodico Cometæ anno* 1770 *observati. Autore* J. A. Lexell, *Academiæ Scientiarum Petrop. Socio. Communicated by* Nevil Maskelyne, *D. D. F. R. S. and Astronomer Royal.*

Read Feb. 20, 1778.

TEMPORIBUS periodicis cometarum investigandis, quum astronomi nondum suas impenderint curas, quod hæc astra intervallo temporis, quo incolis terræ conspicua esse solent, exiguas valde portiones suarum orbitarum conficiant, ita ut exinde vix quicquam certi, de excentricitatibus istarum orbitarum concludi queat; inexspectatum omnino astronomis contigit, quod tempus periodicum cometæ anno 1770 conspicui ex observationibus concludere posse mihi visus sim, mirum autem et vix ulla fide dignum videri debuit, quod hoc tempus periodicum adeo exiguum a me inventum est, ut vix quinque annos cum dimidio superaret, ita ut hic cometa suas periodos circa solem minori adhuc tempore, quam Jupiter et Saturnus absolvere deberet. Propositum quidem mihi nunc non est, omnium calculorum, quibus ad hanc conclusionem perductus sum, adumbrationem hic tradere, quippe quod prolixum valde et pro instituto

tuto minus neceſſarium foret; ſufficit ut argumentum proponam pro iſta hypotheſi temporis periodici ſtabilienda, meo quidem judicio ita ſtringens, ut demonſtrationi geometricæ æquiparari queat. Hujus autem argumenti vis, in eo conſiſtit, ut elementis adhibitis, quæ tempori periodico quinque annorum et ſeptem menſium, conformia ſunt, obſervationibus hujus cometæ optime ſatisfieri demonſtretur, contra vero ſi tempus periodicum cometæ majus ſupponatur, inſignes et vix quidem probabiles errores obſervationibus induci. Sunt igitur elementa, pro motu cometæ a me ſtabilita, ſequentia:

1. Longitudo nodi aſcendentis $4^s\ 12°\ 0'$.

2. Inclinatio orbitæ ad eclipticam $1°\ 33'\ 40''$.

3. Elongatio nodi deſcendentis a perihelio $44°\ 17'\ 4''$, ideoque longitudo perihelii $11^s\ 26°\ 16'\ 26''$.

4. Tempus tranſitus per perihelium anno 1770 die 13 Aug. $13^h\ 5'$ circiter, ſive 13,5450 Aug.

5. Cometæ diſtantia perihelii 0,6743815, cujus log. = 9,8289057.

6. Semiaxis orbitæ a cometa deſcriptæ = 3,1478606, cujus log. = 0,4980155. Hinc log. ſemiparametri = 0,0807300, et log. excentric. = 9,8952927, ideoque tempus periodicum 5,585 annorum.

His elementis adhibitis, ſequentes comparationes locorum cometæ ex theoria deductorum, cum obſervatis, habebuntur.

Jun.

	Temp. med. Paris.	Long. com. obser.	Long. com. ex calculo.	Diff.	Latit. com. observat.	Latit. com. ex calculo.	Diff.
	h ′ ″	s ° ′ ″	s ° ′ ″	′ ″	° ′ ″	° ′ ″	′ ″
Jun. 14	11 29 48	9 2 47 44	9 2 48 1	+0 17	6 40 24B	6 40 54B	+0 30
15	11 23 22	9 2 51 49	9 2 51 54	+0 5	6 57 15	6 57 51	+0 36
17	11 11 33	9 2 59 58	9 3 0 52	+0 54	7 38 51	7 38 37	−0 14
20	10 40 48	9 3 16 12	9 3 17 2	+0 50	9 5 38	9 5 29	−0 9
21	10 27 45	9 3 23 17	9 3 24 26	+1 9	9 44 36	9 45 27	+0 51
22	12 9 36	9 3 33 43	9 3 34 9	+0 26	10 39 5	10 39 54	+0 49
24	12 3 18	9 3 59 58	9 3 59 51	−0 7	12 59 55	12 59 52	−0 3
25	13 27 55	9 4 21 42	9 4 21 21	−0 21	14 53 56	14 54 37	+0 41
27	13 13 17	9 5 34 54	9 5 36 6	+1 12	21 8 47	21 8 38	−0 9
28	10 46 34	9 6 45 58	9 6 43 58	−2 0	26 29 33	26 30 39	+1 6
29	11 59 26	9 9 42 45	9 9 42 30	−0 15	37 57 32	38 0 37	+3 5
Aug. 2	15 3 15	3 6 2 32	3 6 2 4	−0 28	0 50 7A	0 49 59A	−0 8
3	14 45 9	3 6 25 15	3 6 24 32	−0 43	0 53 36	0 52 46	−0 50
4	14 12 48	3 6 47 24	3 6 47 46	+0 18	0 55 44	0 56 4	+0 20
5	14 38 43	3 7 13 53	3 7 13 3	−0 48	0 59 17	0 58 50	−0 27
6	14 29 42	3 7 39 25	3 7 38 45	−0 40	1 1 18	1 1 16	−0 2
7	14 49 19	3 8 6 40	3 8 5 59	−0 41	1 3 35	1 3 34	−0 1
8	14 20 13	3 8 33 29	3 8 33 17	−0 12	1 6 36	1 5 35	−1 1
9	14 48 10	3 9 4 30	3 9 2 40	−1 50	1 9 33	1 7 29	−2 4
10	14 14 27	3 9 32 36	3 9 31 44	−0 52	1 9 13	1 9 9	−0 4
11	14 23 23	3 10 3 2	3 10 2 37	−0 25	1 10 51	1 10 40	−0 11
12	14 46 25	3 10 34 48	3 10 34 43	−0 5	1 12 52	1 12 4	−0 48
14	14 37 29	3 11 40 25	3 11 40 4	−0 21	1 15 25	1 14 25	−1 0
15	15 43 33	3 12 14 56	3 12 15 37	+0 41	1 16 43	1 15 26	−1 17
18	14 24 32	3 13 59 24	3 13 59 37	+0 13	1 18 35	1 17 39	−0 56
19	14 33 18	3 14 36 3	3 14 36 16	+0 13	1 19 18	1 18 37	−0 41
26	15 39 38	3 19 3 44	3 19 3 59	+0 15	1 20 45	1 20 5	−0 40

	Temp. med. Paris.	Long. com. observ.	Long. ex calculo.	Diff.	Latit. com. observat.	Latit. ex calculo.	Diff.
	h ′ ″	s ° ′ ″	s ° ′ ″	′ ″	° ′ ″	° ′ ″	′ ″
Aug. 28	14 44 8	3 20 19 42	3 20 20 27	+0 45	1 20 55A	1 20 5A	−0 50
29	15 21 53	3 21 0 3	3 21 0 31	+0 28	1 20 5	1 20 3	−0 2
30	14 48 22	3 21 39 12	3 21 38 44	−0 28	1 20 56	1 19 58	−0 58
31	14 38 25	3 22 17 16	3 22 17 49	+0 33	1 20 23	1 19 50	−0 33
Sept. 4	15 5 20	3 24 52 41	3 24 53 46	+1 5	1 19 23	1 19 2	−0 21
5	14 48 37	3 25 31 7	3 25 31 44	+0 37	1 19 45	1 18 47	−0 58
8	15 57 4	3 27 26 32	3 27 27 41	+1 9	1 18 23	1 17 51	−0 32
9	15 6 30	3 28 3 19	3 28 3 52	+0 33	1 18 22	1 17 33	−0 49
10	16 26 33	3 28 40 26	3 28 43 15	+2 49	1 19 4	1 17 12	−1 52
14	14 16 26	4 1 4 36	4 1 5 35	+0 59	1 16 18	1 15 46	−0 32
17	15 53 3	4 2 52 40	4 2 53 13	+0 33	1 14 52	1 14 35	−0 17
18	15 30 16	4 3 26 57	4 3 27 6	+0 9	1 14 58	1 14 12	−0 46
19	15 19 4	4 4 0 32	4 4 0 37	+0 5	1 13 2	1 13 48	+0 46
20	15 33 45	4 4 34 17	4 4 34 27	+0 10	1 12 35	1 13 35	+1 0
25	15 23 51	4 9 14 54	4 9 15 53	+0 59	1 10 16	1 9 42	−0 34
Oct. 1	15 23 27	4 10 12 6	4 10 13 31	+1 25	1 9 51	1 8 54	−0 57
——	16 33 28	4 10 13 54	4 10 14 55	+1 1	1 10 4	1 8 53	−1 11
2	15 43 37	4 10 40 51	4 10 41 59	+1 9	1 10 4	1 8 29	−1 35
——	16 38 50	4 10 41 52	4 10 43 5	+1 13	1 10 10	1 8 29	−1 41

Conſenſus itaque theoriæ cum obſervationibus jam quidem tantus eſt, ut vix majorem deſiderare liceat, nam pro longitudinibus aberratio nunquam duo minuta prima ſupergreditur, niſi pro obſervatione die 10 Septembris inſtituta, quæ tamen obſervatio, uti ex comparatione cum reliquis patefiet, non poteſt non aliquantum eſſe dubia.

Pro-

Pro latitudinibus quoque, errores etiamſi plerumque negativum ſortiantur valorem, majores tamen non ſunt, quam ut veriſimiles videri debeant; nam differentia pro obſervatione dici 29 Junii, quæ eſt 3 minutorum, ope parallaxeos cometæ, quæ tum temporis inſignis erat, facilem admittit explicationem. Cæterum facile tamen intelligitur, elementa obſervationibus ſatisfacientia cum aliqua latitudine aſſumi poſſe. Sic ſi tempus periodicum ſtatuatur 5, 6 annorum, log. ſemiparam. orbitæ = 0,0808000, log. diſt. perih. 9,8288794, tempus perihelii = 13,5400 Aug. long. ☊ = 4ˢ 12° 9′, inclinatio orbitæ 1° 33′ 40″, elongatio a ☊ = 44° 7′ 59″, erunt loca cometæ ex calculo.

	‘	°	′	″		°	′	″	
Pro 15 Jun.	long.	9	2	52	12	lat. 6	58	37	Bor.
29		9	9	42	59	38	0	54	
2 Aug.		3	6	2	7	38	49	35	A.
29		3	21	0	33	1	20	1	
1 Octob.		4	10	13	20	1	9	0	

Quæ loca æque bene, vel aliquanto melius cum obſervatione conſentiunt, ac quæ ſupra attulimus. Nunc igitur diſpiciamus an tempus periodicum inſignius auctum, elementis inveniendis inſerviat quæ cum obſervationibus componi queant. Supponamus igitur primum omnes obſervationes ad unam eandemque orbitam cometæ per-

tinere, seu quod idem est, cometam in approximatione sua ad tellurem, ab actione telluris affectum non fuisse; deinde enim visuri erimus, quid statuendum sit, si supponatur actionem telluris in motum cometæ aliquem habuisse influxum. Jam igitur assumpto certo tempore periodico, uti primum 6 annorum, et adhibito certo valore pro semiparametro orbitæ, in reliqua ejus elementa inquisivi quæ ita essent comparata, ut observationibus diebus 15 et 29 Junii institutis, satisfacerent; patet enim quod si bina cometæ elementa, uti tempus periodicum et parameter orbitæ, pro cognitis habeantur, omnia quæ ad motum cometæ stabiliendum desiderantur, ope duarum observationum investigari posse.

Positis itaque nunc, tempore periodico 6 annorum, et log. semipar. = 0,6817000, reliqua elementa erunt; log. dist. perih. = 9.8273218, temp. perih. = 13,2850 Augusti, long. ☊ = 4ˢ 12° 6′, inclinatio orbitæ = 1° 34′ 30″, elong. perih. a ☊ = 44° 9′ 56″. Hincque loca cometæ ex calculo.

		°	′	″		°	′	″	
Pro 15 Jun.	long.	9	2	51	52	lat.	6	58	6 Bor.
29		9	9	43	6		38	0	27
2 Aug.		3	6	3	18		38	50	15
29		3	21	5	42		1	20	6
1 Oct.		4	10	11	54		1	9	19

Suppoſito iterum tempore periodico 6 annorum et log. ſemipar. = 0,0818500 erit tempus perihelii 13,2900 Aug. long. ☊ = 4ˢ 12° 28′, inclinatio orbitæ = 1° 34′ 2″, elong. perihel. a ☉ = 43° 37′ 28″, tumque erunt:

	Comet. longit.				Latitud.			
	ˢ	°	′	″	°	′	″	
Pro 15 Jun.	9	2	51	25	6	58	6	Bor.
29	9	9	42	42	38	0	24	
2 Aug.	3	6	2	47	0	49	3	Auſt.
29	3	21	4	56	1	19	36	
1 Oct.	4	10	10	59	1	9	1	

Pro hac igitur poſteriori hypotheſi, obſervationibus dierum 2 et 29 Aug. reſpectu longitudinis quidem melius ſatisfit, quam per priorem hypotheſin, ac obſervatio die 1 Octobr. reſpectu longitudinis jam magis evadit erronea, tumque etiam reſpectu latitudinis errores aliquantum augentur; concludi autem hinc quoque poteſt, quæcunque etiam ſuppoſitio fiat pro ſemiparametro orbitæ ſi tempus periodicum ſtatuatur 6 annorum, et obſervationibus diebus 15 et 29 Junii ſatisfaciendum ſit, obſervationes occurrere, quæ erroribus ſaltem duorum minutorum, tam negativis quam poſitivis afficientur. Quod ſi jam ſupponatur tempus periodicum 7 annorum et log. ſemiparam. = 0,0837000, erit tempus perihelii 12,7950 Auguſt. long. ☊ = 4ˢ 12° 49′, inclinatio orbitæ

= 1° 35′ 30″, elongatio perihelii a ☊ = 43° 26′ 10″, tumque habebuntur:

	Com. longit.				Latitudo.			
		°	′	″	°	′	″	
Pro 15 Jun.	9	2	52	1	6	58	16	Bor.
29	9	9	42	50	38	0	28	
2 Aug.	3	6	6	19	38	49	3	Auſt.
29	5	21	16	18	1	19	31	
1 Oct.	4	10	9	22	1	9	17	

Deinde adhibito iterum tempore periodico 7 annorum et log. ſemipar. = 0,0840000, erit tempus perihelii = 12,8050 Aug. long. ☊ = 4ˢ 13° 58′, inclinatio orbitæ = 1° 33′ 50″, et long. perih. a ♈ = 42° 14′ 41″, hincque ſequuntur.

		°	′	″		°	′	″	
Pro 15 Jun.	long.	9	2	51	54	lat.	6	58	30	B.
29		9	9	42	38		38	0	30	
2 Aug.		3	6	5	59		38	45	25	A.
29		3	21	13	54		1	17	57	
1 Oct.		4	10	6	2		1	9	13	

Poſteriori adhibita hypotheſi, errores obſervationum die 2 et 29 Aug. inſtitutarum, quoad longitudinem aliquantum minuuntur, in latitudinem autem tanto majores, redundant, tumque obſervatio die 1 Oct. inſtituta ſecundum poſteriorem hypotheſin multo magis redditur erronea. Certum igitur eſt cum tempore periodico ſeptem

annorum omnes obſervationes circa cometam anni 1770 nulla ratione impleri poſſe; quin potius adeo enormes errores in nonnullas earum redundare, ut vix ullam invenire queant fidem. Reſtat autem nunc, ut examinemus, an ne ſaltem omnibus obſervationibus a die 2 Auguſti uſque ad 2 Octobris inſtitutis, ſatisfieri queat; adhibito tempore periodico aliquantum majori. Et tum quidem evidens eſt, quia arcus cometæ circa ſolem deſcriptus 2 2 Auguſti uſque ad 2 Octobris, multo minor eſt illo, quem a 15 Jun. ad 2 Octobris percurrit, tempus periodicum quo obſervationibus ſecundæ apparitionis ſatisfaciendum ſit, jam cum majori latitudine aſſumi poſſe, quam ſi omnibus in univerſum obſervationibus ſatisfaciendum eſſet. Hinc igitur ſi tempus periodicum ſtatuetur 6 annorum, ejuſmodi quidem elementa facile inveniri poſſunt, ut obſervationes a 2 Aug. ad 2 Octobris factæ, ſaltem abſque gravioribus erroribus, impleantur. Diſpiciamus itaque quid evenire debeat, ſi tempus periodicum ſtatuatur 7 annorum. Generatim igitur quum compertum mihi fuerit, latitudinibus cometæ facile ſatisfieri, modo longitudinibus fuerit ſatisfactum, operam dedi, ut tribus cometæ longitudinibus obſervatis ſatisfacerem; tumque examinavi qualis error in quartam aliquam obſervationem redundaret. Quatuor autem obſervationes, quarum ubique uſum feci ſunt illa, quæ diebus 2, 12, 29 Aug. et 1 Oct.

institutæ habentur. Primum igitur elementa investigavi, quibus observationes dierum 2, 29 Augusti. et 1 Octobris implentur, quæ sequentia mihi se obtulerunt.

Log. semipar. = 0,0925000, tempus perih. = 15,6280 Augusti, elong. perih. a ☿ = 46° 14′ 6″, posita longitudine ☊ = 4ˢ 12° 0′, loca autem cometæ ex theoria deducta, nunc ita se habebunt:

Longitudo cometæ.

	ˢ	°	′	″
Pro 2 Aug.	3	6	2	27
12	3	10	41	45
29	3	21	0	20
1 Oct.	4	10	12	29

Ubi in observatione die 12 Augusti facta reperitur error 7 minutorum primorum. Deinde aliis calculis comperi, quod si sub hypothesi temporis periodici 7 annorum observationes dierum 2 Aug. et 1 Octobris impleantur, quicunque demum error in observatione die 29 Augusti admittatur, errorem observationis die 12 Augusti factæ, nunquam infra 7 minuta prima deprimi posse; unde tanto magis concludere licet, aucto tempore periodico, observationes dierum 2, 12 Aug. et 1 Octob. multo minus inter se componi posse. Ulterius pergendo, operam dedi ut observationes diebus 12 et 29 Aug. atque 1 Oct. factas implerem, quod sequentibus elementis obtinui.

Log.

Log. ſemi-par. = 0,0915000, temp. perih. = 15,1340 Aug. elong. perih. a ☌ = 45° 59′ 24″, poſita longitudine nodi ut ſupra, tum enim erant:

	Longitud. cometæ.			
	☌	°	′	″
Pro 2 Aug.	3	5	49	1
12	3	10	34	41
29	3	21	0	20
1 Oct.	4	10	12	6

Ubi obſervatio die 2 Auguſti facta, 13 minutis primis redditur erronea, qui etiam minimus fere error eſt, quem hæc obſervatio admittit, dum obſervationes dierum 12 Aug. et 1 Octob. ſub hypotheſi temporis periodici ſeptem annorum implendæ ſunt. Deinde ſi idem adhibeatur tempus periodicum, et obſervationibus dierum 2, 12, et 29 Aug. ſatisfactum ſit, quod fiet ponenda log. ſemipar. = 0,0837600, tempus perih. = 12,1500 Auguſt, elongat. a ☌ = 43° 16′ 33″, longit. nodi ut ſupra, in obſervatione die 1 Octobris inſtituta, reperietur error 35 min. prim. Omnes autem hæ diſquiſitiones eo tendunt, ut perficiatur, obſervationes a 2 Aug. uſque ad 2 Octob. inſtitutas, ſub hypotheſi temporis periodici 7 annorum nunquam perfecte impleri poſſe, ſed inter illas ſaltem nonnullas occurrere, quæ erroribus 7 minut. primorum obnoxiæ ſunt, quod quidem vix ulla veriſimilitudine

tudine gaudet. Quamvis hinc facile concludi possit, aucta quantitate temporis periodici, errores observationum augeri, ipsemet tamen calculo instituto ea de re certior fieri volui. Posito itaque tempore periodico 8 annor. log. semipar. = 0,1000000, tempore perih. = 17,2300, elong. perih. a ☉ = 47° 32′ 4″, long. ☊ ut supra adhibita sequentes inveni longitudines cometæ.

	°	′	″
Pro 2 Aug.	3	6	2 44
12	3	10	47 42
15	3	12	26 33
29	3	21	0 57
1 Oct.	4	10	12 6

Ubi jam in observatione die 12 Aug. instituto, occurrit error 13 minutorum primorum. Tum vero me non monente intelligitur, quod suppositâ tempore periodico septem annorum, quæcunque demum elementa adhibeantur inter illa, quæ observationibus secundæ apparitionis satisfacere debent, inde enormes omnino errores pro observationibus primæ apparitionis emergere. Operæ quidem pretium non esse judicavi, ut inquirerem, an valor temporis periodici allatus sensibilem admittat diminutionem, quia hoc unicuique minus probabile videbitur; ex iis autem, quæ jam attuli, facile colligitur, si omnibus in universum observationibus satisfaciendum sit, tempus periodicum

periodicum allatum vix dimidia parte anni infra illum valorem, quem ſuppoſui, deprimi poſſe; ſin autem obſervationibus ſecundæ apparitionis ſolummodo ſatisfaciendum ſit, omnes quidem valores temporis periodici intra limites 5 et 6 annorum contenti, abſque metu ſenſibilis erroris in obſervationes redundantis admitti poſſent. Exiſtimaverim tamen hos limites nullo modo ultra quatuor annos cum dimidio et 6 annos cum dimidio prorogari poſſe, quin potius maxime mihi eſt vero ſimile, valorem temporis periodici, arctioribus iſtis limitibus 5, vel 6 annorum circumſcribi.

Quo autem certius eſt argumentum; quod pro ſtabiliendo tempore periodico cometæ anno 1770 obſervati, jam propoſui, eo ſane magis unicuique mirum videri debet, quod hunc eundem cometam non niſi unica vice obſervare licuerit. Nam ſi hic cometa ſingulis quinque annis et ſeptem menſibus ad ſuum rediret perihelium, utique fieri debuiſſe videtur, ut ſaltem hoc ſeculo, poſtquam ſtudium cœlorum majori aſſiduitate cœli cœptum eſt, ſæpius ſe conſpiciendum præbuiſſet. Cum variæ quidem conjecturæ proponi poſſent pro explicando eventu adeo ſingulari, tum inter illas eam adferre, quæ maxima probabilitate ſe commendat, hac occaſione ſufficiet. Quum diſtantia aphelia cometæ a ſole, diſtantiam Jovis ab hoc aſtro fere exæquet, ſtatim ſuſpicio quædam

ſuboritur,

ſuboritur, an non fieri potuit, ut per actionem Jovis, motus cometæ olim fuerit perturbatus, ita ut cometa hic antehac orbitam, a præſenti multo diverſam, deſcripſerit. Calculo autem inſtituto reperitur, cometam fuiſſe in conjunctione cum Jove, Anno 1767, die 27 Maii, eorumque diſtantiam tum temporis fuiſſe 58vam partem diſtantiæ cometæ a ſole, unde habito reſpectu maſſarum Solis et Jovis, colligitur actionem Jovis in cometam fuiſſe triplo majorem actione Solis, ideoque ſenſibilem omnino effectum ad motum cometæ perturbandum producere valuiſſe; eo potius quod in aphelio cometa motu admodum lento feratur, adeoque ſatis diu actioni Jovis fuerit expoſitus. Ulterius per elementa ſupra a nobis ſtabilita colligitur, proxime futuram conjunctionem Jovis cum cometa contingere debere anno proxime ſequenti die 23 Auguſti, exiſtente tunc diſtantia cometæ a Jove non niſi 491^ma parte diſtantiæ cometæ a Sole, ideoque actionem Jovis in cometam actione Solis 224 vicibus majorem eſſe, unde totalis mutatio motus cometæ non poterit non oriri. Cæterum hæ concluſiones pro exacte veris haberi non poterunt, niſi quatenus elementa pro motu cometæ allata, fuerint exactiſſime ſtabilita; quippe quum leviſſima mutatio horum elementorum, imprimiſque temporis periodici, diſtantiam cometæ apheliam ſenſibili mutatione afficiat, et per facilem calculum exploravi

quod ſi tempus periodicum cometæ aliquantulum diminuatur, eo effici ut actio Jovis in priori conjunctione augeatur, contra vero in poſteriori conjunctione diminuatur. Hoc igitur ratiocinio id præ-primis mihi fuit propoſitum, ut oſtenderem, fieri utique potuiſſe, quod hic cometa ob actionem Jovis coactus fuerit ejuſmodi orbitam deſcribere, quæ ex obſervationibus anno 1770 factis colligitur, licet antea motum ſuum perfecerit in orbita, cujus tempus periodicum ſatis inſigne eſſe potuerit. Utrum cometa noſter in approximatione ſua ad tellurem, ab actione telluris fuerit affectus, id quidem nec affirmare nec negare auſim, ſaltem veriſimile mihi videtur, hanc actionem non admodum ſenſibiles mutationes producere valuiſſe, et ex ſuperioribus quidem conſtat, pro tempore periodico cometæ non admodum magnas alterationes oriri potuiſſe.

Denique licet valde dubium eſſe queat, utrum cometa noſter in proximo ad perihelium acceſſu, nobis ſe conſpiciendum præbeat, quod motus ejus ab actione Jovis totalem forſan ſubierit mutationem; tamen aſtronomis haud prorſus ingratum eſſe exiſtimaverim, ſi tabulam ſubjunxerim, quæ oſtendet in quibuſnam cœli regionibus ſingulis menſibus cometam hunc quærere oporteat, reſpectu quoque habito ad majores vel minores valores temporis periodici, limitibus 5 et 6 annorum contentos.

	Long.	Latit.	Long.	Latit.	Long	Latit	Long.	Latit.	Long.	Latit.
	°	° ′	°	° ′	°	° ′	° ′	° ′	°	° ′
Maii 1	0 13*	0 14A	11 12	0 49B	10 5	2 7B	8 27	2 55B		
15	0 5	0 20B	10 26	2 6	9 1	3 29	7 29	3 13		
Jun. 1	1 3	0 18A	11 27	1 33	9 3	4 41	7 22	3 25		
15	1 0	0 30B	9 4	7 7	7 12	3 18	7 3*	2 38		
Jul. 1	1 26	0 25A	in conj. cum ☉		7 5	2 56	7 0*	2 17		
15	in conj. cum ☉		6 29	2 29	6 29*	1 59				
Aug. 1	3 5	0 49A	6 24	1 37	7 1*	1 36				
15	3 12	1 16	6 23	0 51	7 4*	1 17				
Sept. 1	3 23	1 19	6 1	0 58A	7 10	0 50				
15	4 1	1 15	5 8	2 10	7 16	0 27				
Oct. 1	4 10	1 9	4 22	2 27	7 24	0 31A				
15	4 21	2 13	7 27	1 34						
Nov. 1	4 22	1 58	7 14	5 8	8 22	1 5				
15	4 20	1 52	6 25	6 1	9 6	0 54				
Dec. 1	4 10	1 37	4 15	7 44	10 4	5 42	10 20	2 55A		
15	4 0	1 20	3 22	4 31	9 3	19 7	10 29	3 14	9 28	0 39A
Jan. 1	3 5	2 36	0 13	3 12	10 28	1 16A				
15	3 0	1 42	1 10	2 19	11 23	1 32	10 18*	0 31		
Feb. 1	3 1	1 2	2 5	1 0	0 23	1 26	11 19*	0 57		
15	3 4*	0 40	0 10*	1 2	11 8*	0 28	10 14*	0 9B		
Mar. 1	0 3*	0 44	11 6*	0 12	10 12*	0 28B				
15	0 24*	0 49	11 24*	0 29	11 1*	0 10				
Apr. 1	11 25*	0 12	10 28*	0 33B	10 1*	1 21				
15	0 16*	0 29	11 18*	0 12	10 17*	1 13				

De hac tabula notari convenit, quod in illa saltus non nunquam majores prodeant, quod inde evenit, quia ex una columna verticali in præcedentem transitus factus sit;

ſic ſi ſupponatur tempus perihelii incidere in 13 Junii, erit pro 1 Junii longitudo cometæ 11ˢ 27° et latitudo 1° 33′, quæ in columna verticali ſecunda allegantur; pro 15 autem Junii, erit longitudo 1ˢ 0° et latitudo 30′ bor. quæ in columna verticali prima afferuntur. Fundamentum autem cui conſtructio hujus tabulæ innititur, in eo poſitum eſt, quod ſuppoſuerim cometam ſi incolis telluris conſpicuus evadat, non multo magis a terra debere eſſe remotum, ac erat dum anno 1770 menſe Octobris conſpicuus eſſe deſiit, hincque etiam loca in tabula noſtra aſteriſcis notata indicant, dubium eſſe, an cometa in his locis viſibilis fiat.

IN a pamphlet of eighteen pages in quarto, publiſhed at Upſal in 1776, Mr. ERIC PROSPERIN, member of the Royal Academies of Sciences at Stockholm and Upſal, and Aſtronomer to the king of Sweden, has ſhewn by his calculations, that the obſervations of near four months made on this comet by M. MESSIER could not be repreſented by a parabolic orbit; and founds a ſtrong conjecture thereon, and on the circumſtances of the different parabolas which he found neceſſary to repreſent the motion of the comet at different periods of time during its

appearance, that its orbit may be ſenſibly elliptical (which it ſeems M. PINGRE, who firſt calculated the orbit in a parabola, had alſo ſome ſuſpicion of) and concludes with recommending the inveſtigation of the true elements of its orbit in an ellipſis. The laborious calculation thus recommended has, we ſee, been ſince ſucceſſfully and ſatisfactorily performed in this paper by Mr. LEXELL.

N. MASKELYNE.

IX. *On the General Reſolution of Algebraical Equations.* *by* Edward Waring, *M. D. F. R. S. and of the Inſtitute of* Bononia, *Lucaſian Profeſſor of Mathematics in the Univerſity of* Cambridge.

Read Jan. 28, 1779.

IN the year 1757 I ſent ſome papers to the Royal Society, which papers were printed in the year 1759, and copies of them delivered to ſeveral perſons; theſe papers ſomewhat corrected, with the addition of a ſecond part on the properties of curve lines, were publiſhed in the year 1762. In the years 1767, 1768 and 1769 I printed, and publiſhed in the beginning of the year 1770, the ſame papers with additions and emendations under the title of Meditationes Algebraicæ. In theſe papers were contained, with many other inventions, the moſt general reſolution of algebraical equations known, as it contains the reſolution of every algebraical equation, of which the general reſolution has been given, viz. the reſolution of quadratic, cubic and biquadratic, the reſolution of Mr. DE MOIVRE's and Mr. BEROUT's (ſince publiſhed) equations; it diſcovers the reſolution

reſolution of an equation of n dimenſions, of which the n roots are given, and alſo deduces innumerable equations of n dimenſions, which contain $n-1$ independent coefficients. From whence it ſeems probable, that this new method of mine may contain the moſt general reſolution of algebraical equations that ever has, or, perhaps, ever will be invented.

The general reſolution is $x = a\sqrt[n]{p} + b\sqrt[n]{p^2} + c\sqrt[n]{p^3} + d\sqrt[n]{p^4} \ldots + r\sqrt[n]{p^{n-3}} + s\sqrt[n]{p^{n-2}} + t\sqrt[n]{p^{n-1}} + \frac{A}{n}$, if the equation be $x^n - Ax^{n-1} + Bx^{n-2} - Cx^{n-3} + Dx^{n-4} - \&c. = 0$.

I ſhall add the reſolution of ſome particular equations from this method, and then ſubjoin the equation to which $x = a\sqrt[n]{p} + b\sqrt[n]{p^2} + c\sqrt[n]{p^3} + \&c.$ is the general reſolution.

1. Let the reſolution be $x = a\sqrt[3]{p} + b\sqrt[3]{p^2}$, and the correſpondent equation free from radicals will be found $x^3 - 3abpx - a^3p - b^3p^2 = 0$. Let $x^3 - Px - Q = 0$ be a cubic equation whoſe reſolution is required, which ſuppoſe the ſame as the equation found above, and conſequently their correſpondent terms equal, i. e. $P = 3abp$ and $Q = a^3p + b^3p^2$, whence $p = \frac{P}{3ab}$, which value being ſubſtituted for p in the ſecond equation, there reſults $Q = \frac{Pa^3}{3b} + \frac{bP^2}{9a^2}$. In this equation for a or b may be aſſumed unity, or any other

other quantity whatever, and there will result an equation of the formula of a quadratic from which the other b or a may be found, whence from the equation $(p = \frac{P}{3ab})$ p may be deduced, and consequently the resolution of the cubic required.

In the same manner for p may be assumed any quantity whatever, and in the equation $Q = a^3p + b^3p^2$ for b substitute its value $\frac{P}{3ap}$, or for a its value $\frac{P}{3bp}$, and there result the equations $Q = a^3p + \frac{P^3}{27a^3p}$, and $Q = \frac{P^3}{27b^3p^3} + b^3p^2$, which have the formula of a quadratic, from which may be deduced the resolution of the cubic required.

2. Let the resolution assumed be $x = a\sqrt[4]{p} + b\sqrt[4]{p^3} + c\sqrt[4]{p^3}$; exterminate the irrational quantities, and there results the equation $x^4 - (2b^2 + 4ac)px^2 - 4(a^2bp + bc^2p^2)x - a^4p + b^4p^2 - c^4p^3 + 2a^2c^2p^2 - 4ab^2cp^2 = 0$; suppose $p = 1$, and the given equation $x^4 + qx^2 - rx + s = 0$, let the correspondent terms of the given and resulting equations be respectively made equal to each other, and there result the three equations $2b^2 + 4ac = -q$, $4b(a^2 + c^2) = r$, and $a^4 - b^4 + c^4 - 2a^2c^2 + 4ab^2c = -s$; reduce these equations into one, so that the unknown quantities a and c may be exterminated, and there results the equation $4b^6 + 2qb^4 + (\frac{q^2}{4} - s)b^2 - \frac{r^2}{16} = 0$ of the formula of a cubic, from whi

the

the unknown quantity b may be found, which being substituted for its value (b) in the preceding equations, from the equations thence ensuing may be found the unknown quantities a and c, and consequently the resolution of the given biquadratic $x^4+qx^2-rx+s=0$.

From the same principles can be deduced different resolutions of the above-mentioned biquadratic $x^4+qx^2-rx+s=0$.

3. I. Let $x=a\sqrt[2n]{p}+b\sqrt[2n]{p^2}$, then will the equation free from radicals be $x^{2n}-2b^npx^n-\frac{n}{1.2}.2nb^{n-1}a^2px^{n-1}-\frac{n\times\overline{n^2-1}}{1.2.3.4}\times 2nb^{n-2}a^4px^{n-3}-\frac{n\times\overline{n^2-1}\times\overline{n^2-4}}{1.2.3.4.5.6}\times 2nb^{n-3}a^6px^{n-3}-\frac{n.\overline{n^2-1}.\overline{n^2-4}.\overline{n^2-9}}{1.2.3.4.5.6.7.8}\times 2nb^{n-4}a^8px^{n-4}\ldots\ldots\ldots-\frac{n.\overline{n^2-1}\times\overline{n^2-4}\times\overline{n^2-9}.\overline{n^2-16}\ldots\overline{n^2-n-2}}{1.2.3.4.5.6.7\ldots\ldots 2n-2}\times 2na^{2n-1}bpx=a^{2n}p-b^{2n}p^2$.

This equation may be deduced from the following principles. Let α, β, γ, δ, ε, &c. be the $2n$ roots of the equation $z^{2n}-1=0$, then (by Prop. XXIII. of my Meditat. Algebraicæ) the equation free from radicals will be the product of the following quantities $(x-a\alpha\sqrt[2n]{p}-b\alpha^2\sqrt[2n]{p^2})(x-a\beta\sqrt[2n]{p}-b\beta^2\sqrt[2n]{p^2})(x-a\gamma\sqrt[2n]{p}-b\gamma^2\sqrt[2n]{p^2})(x-a\delta\sqrt[2n]{p}-b\delta^2\sqrt[2n]{p^2})(x-a\varepsilon\sqrt[2n]{p}-b\varepsilon^2\sqrt[2n]{p^2})$ &c. $=0$: multiply these quantities into each other, and from the resulting product, by Prob. III. of the Meditat. Algebr. easily can

be deduced the equation free from radicals which was to be found.

3. II. Let $x=a\sqrt[2n+1]{p}+b\sqrt[2n+1]{p^2}$, then will the correſpondent equation free from radicals be $x^{2n+1}-\overline{2n+1}\,b^n apx^n-\frac{n.n+1}{1.2.3}\times\overline{2n+1}\,b^{n-1}a^3px^{n-1}-\frac{n\times n^2-1\times n+2}{1.2.3.4.5}\times\overline{2n+1}\,b^{n-2}a^5px^{n-2}-\frac{n\times n^2-1\times n^2-4\times n+3}{1.2.3.4.5.6.7}\times\overline{2n+1}\,b^{n-3}a^7px^{n-3}-\frac{n.n^2-1.n^2-4.n^2-9.n+4}{1.2.3.4.5.6.7.8.9}\times\overline{2n+1}b^{n-4}a^9px^{n-4}-\ldots.-\frac{n.n^2-1.n^2-4.n^2-9.n^2-16\ldots n^2-n-1^2\times 2n-1}{1.2.3.4.5.6.7.8.9\ldots 2n-1}\times\overline{2n+1}\,ba^{2n-1}px=a^{2n+1}p+b^{2n+1}p^2$.

This may be derived from the ſame principles as the preceding.

3. III. In general let the equation be $x=a\sqrt[m]{p}+b\sqrt[m]{p^2}$, then will the equation free from radicals become $x^m-ma^{m-2}bpx-m.\frac{m-3}{2}a^{m-4}b^2px^2-m.\frac{m-4}{2}.\frac{m-5}{3}a^{m-6}b^3px^3-m.\frac{m-5}{2}.\frac{m-6}{3}.\frac{m-7}{4}a^{m-8}b^4px^4-m.\frac{m-6}{2}.\frac{m-7}{3}.\frac{m-8}{4}.\frac{m-9}{5}a^{m-10}b^5px^5-$ &c. $=a^mp\pm b^mp^2$; if m denotes an even number, it will be $-b^mp^2$, but if an odd number, it will be $+b^mp^2$.

4. I. Let n denote an odd number, and $x=a\sqrt[n]{p}+b\sqrt[n]{p^2}$, then will $x^n-p\,(na^{n-2}bx^2+n.\frac{n-5}{2}a^{n-6}b^2x^4+n.\frac{n-7}{2}.\frac{n-8}{3}a^{n-9}b^3x^5+n.\frac{n-9}{2}.\frac{n-10}{3}.\frac{n-11}{4}a^{n-12}b^4x^8+n.\frac{n-11}{2}.\frac{n-12}{3}.\frac{n-13}{4}.\frac{n-14}{5}a^{n-15}b^5x^{10}+n.\frac{n-13}{2}.\frac{n-14}{3}.\frac{n-15}{4}.\frac{n-16}{5}.\frac{n-17}{6}a^{n-18}b^6x^{12}+n.$

n—

$\frac{n-15}{2}\cdot\frac{n-16}{3}\cdot\frac{n-17}{4}\cdot\frac{n-18}{5}\cdot\frac{n-19}{6}\cdot\frac{n-20}{7}\,a^{n-21}b^7x^{14}$ + &c.) $\pm p^3$ $(na^{\frac{n-1}{2}}$
$b^{\frac{n+1}{2}}x - \frac{1}{2^3}\times n.\frac{n-5}{2}\cdot\frac{n-7}{3}\,a^{\frac{n-9}{2}}b^{\frac{n+3}{2}}x^3 + \frac{1}{2^5}\times n.\frac{n-7}{2}\cdot\frac{n-9}{3}\cdot\frac{n-11}{4}\cdot\frac{n-13}{5}$
$a^{\frac{n-15}{2}}b^{\frac{n+5}{2}}x^5 - \frac{1}{2^6}\times n.\frac{n-9}{2}\cdot\frac{n-11}{3}\cdot\frac{n-13}{4}\cdot\frac{n-15}{5}\cdot\frac{n-17}{6}\cdot\frac{n-19}{7}\,a^{\frac{n-21}{2}}b^{\frac{n+7}{2}}x^7 +$
$\frac{1}{2^8}\times n.\frac{n-11}{2}\cdot\frac{n-13}{3}\cdot\frac{n-15}{4}\cdot\frac{n-17}{5}\cdot\frac{n-19}{6}\cdot\frac{n-21}{7}\cdot\frac{n-23}{8}\cdot\frac{n-25}{9}\,a^{\frac{n-27}{2}}b^{\frac{n+9}{2}}x^9 -$
&c.) $= a^n p + b^n p^3$.

The quantity $\pm p^3$ denotes $+p^3$ if $\frac{n-3}{4}$ is a whole number, otherwise $-p^3$.

4. II. Let n denote an even number, and x as before $= a\sqrt[n]{p} + b\sqrt[n]{p^3}$, then will $x^n - p$ $(na^{n-3}bx^2 + n.\frac{n-5}{2}\,a^{n-6}b^2x^4$
$+ n.\frac{n-7}{2}\cdot\frac{n-8}{3}\,a^{n-9}b^3x^6 + n.\frac{n-9}{2}\cdot\frac{n-10}{3}\cdot\frac{n-11}{4}\,a^{n-12}b^4x^8 + n.\frac{n-11}{2}\cdot$
$\frac{n-12}{3}\cdot\frac{n-13}{4}\cdot\frac{n-14}{5}\,a^{n-15}b^5x^{10}$ + &c.) $\pm p^2$ $(\frac{1}{2}n.\frac{n-4}{2}\,a^{\frac{n-6}{2}}b^{\frac{n+2}{2}}x^2 -$
$\frac{1}{2^3}\times n.\frac{n-6}{2}\cdot\frac{n-8}{3}\cdot\frac{n-10}{4}\,a^{\frac{n-12}{2}}b^{\frac{n+4}{2}}x^4 + \frac{1}{2^5}\times n.\frac{n-8}{2}\cdot\frac{n-10}{3}\cdot\frac{n-12}{4}\cdot\frac{n-14}{5}\cdot$
$\frac{n-16}{6}\,a^{\frac{n-18}{2}}b^{\frac{n+6}{2}}x^6 - \frac{1}{2^7}\times n.\frac{n-10}{2}\cdot\frac{n-12}{3}\cdot\frac{n-14}{4}\cdot\frac{n-16}{5}\cdot\frac{n-18}{6}\cdot\frac{n-20}{7}\cdot\frac{n-22}{8}$
$a^{\frac{n-24}{2}}b^{\frac{n+8}{2}}x^8$ + &c.) $= a^n p + b^n p^3 \pm 2a^{\frac{n}{2}}b^{\frac{n}{2}}p^2$.

The quantities $\pm p^2$ and $\pm 2a^{\frac{n}{2}}b^{\frac{n}{2}}p^2$ denote $+p^2$, and $+2a^{\frac{n}{2}}b^{\frac{n}{2}}p^2$, if $\frac{n-2}{4}$ is a whole number, otherwise they denote $-p^2$ and $-2a^{\frac{n}{2}}b^{\frac{n}{2}}p^2$ respectively.

5. I. Let $x = a\sqrt[n]{p} + b\sqrt[n]{p^{n-1}}$, and n an odd number,

then will $x^n - nabpx^{n-2} + n.\frac{n-3}{2}a^2b^2p^2x^{n-4} - n.\frac{n-4}{2}.\frac{n-5}{3}$
$a^3b^3p^3x^{n-6} + n.\frac{n-5}{2}.\frac{n-6}{3}.\frac{n-7}{4}a^4b^4p^4x^{n-8} - \&c. = a^np + b^np^{n-1}$.

5. II. Let $x = a\sqrt[n]{p} + b\sqrt[n]{p^{n-1}}$, and n an even number, then will $x^n - nabpx^{n-2} + n.\frac{n-3}{2}a^2b^2p^2x^{n-4} - n.\frac{n-4}{2}.$
$\frac{n-5}{3}a^3b^3p^3x^{n-6} + n.\frac{n-5}{2}.\frac{n-6}{3}.\frac{n-7}{4}a^4b^4p^4x^{n-8} - \&c. = a^np \mp$
$2a^{\frac{n}{2}}b^{\frac{n}{2}}p^{\frac{n}{2}} + b^np^{n-1}$; it will be $+ 2a^{\frac{n}{2}}b^{\frac{n}{2}}p^{\frac{n}{2}}$ if $n = 4r + 2$;
but $- 2a^{\frac{n}{2}}b^{\frac{n}{2}}p^{\frac{n}{2}}$ if $n = 4r$.

6. I. Let $x = a\sqrt[n]{p} + b\sqrt[n]{p^{n-2}}$, and n an odd number, which has not the number 3 for a divisor, then will
$x^n - na^2bpx^{n-3} + n.\frac{n-5}{2}a^4b^2p^2x^{n-6} - n.\frac{n-7}{2}.\frac{n-8}{3}a^6b^3p^3x^{n-9} +$
$n.\frac{n-9}{2}.\frac{n-10}{3}.\frac{n-11}{4}a^8b^4p^4x^{n-12} - n.\frac{n-11}{2}.\frac{n-12}{3}.\frac{n-13}{4}.\frac{n-14}{5}$,
$a^{10}b^5p^5x^{n-15} + n.\frac{n-13}{2}.\frac{n\times 14}{3}.\frac{n-15}{4}.\frac{n-16}{5}.\frac{n-17}{6}a^{12}b^6p^6x^{n-6} - \&c.$
(to m terms, where m is the number either equal to, or the leaſt greater than $\frac{n}{3}$) $- ab^{\frac{n+1}{2}}p^{\frac{n-1}{2}}(nx^{\frac{n-3}{2}} + \frac{1}{4}n.\frac{n-5}{2}.\frac{n-7}{3}$
$a^2bpx^{\frac{n-9}{2}} + \frac{1}{2^6}n.\frac{n-7}{2}.\frac{n-9}{3}.\frac{n-11}{4}.\frac{n-13}{5}a^4b^2p^2x^{\frac{n-15}{2}} + \frac{1}{2^6}\times n.\frac{n-9}{3}.$
$\frac{n-11}{3}.\frac{n-13}{4}.\frac{n-15}{5}.\frac{n-17}{6}.\frac{n-19}{7}a^6b^3p^3x^{\frac{n-21}{2}} + \frac{1}{2^8}\times n.\frac{n-11}{2}.\frac{n-13}{3}.\frac{n-15}{4}.$
$\frac{n-17}{5}.\frac{n-19}{6}.\frac{n-21}{7}.\frac{n-23}{8}.\frac{n-25}{9}a^8b^4p^4x^{\frac{n-27}{2}} + \&c.) = A = a^np +$
b^np^{n-1}.

Let n be an odd number diviſible by 3, then will the above-

above-mentioned quantity $= A = a^n p + b^n p^{n-1} + 3a^{\frac{n}{3}} b^{\frac{2n}{3}} p^{\frac{2n}{3}-1} + 3a^{\frac{2n}{3}} b^{\frac{n}{3}} p^{\frac{n}{3}}$.

6. II. Let n be an even number, not divisible by 3, then will $x^n - na^2bpx^{n-3} + n.\frac{n-5}{2} a^4b^2p^2x^{n-6} - n.\frac{n-7}{2}.\frac{n-8}{3} a^6b^3p^3x^{n-9} + n.\frac{n-9}{2}.\frac{n-10}{3}.\frac{n-11}{4} a^8b^4p^4x^{n-12} - n.\frac{n-11}{2}.\frac{n-12}{3}.\frac{n-13}{4}.\frac{n-14}{5} a^{10}b^5p^5x^{n-15} + n.\frac{n-13}{2}.\frac{n-14}{3}.\frac{n-15}{4}.\frac{n-16}{5}.\frac{n-17}{6} a^{12}b^6p^6x^{n-18} -$ &c. to m terms as before $- b^{\frac{n}{2}} p^{\frac{n}{2}-1} (2x^{\frac{n}{4}} + \frac{1}{2^2} n.\frac{n-4}{2} a^2bpx^{\frac{n}{2}-3} + \frac{1}{2^3} \times n.\frac{n-6}{2}.\frac{n-8}{3}.\frac{n-10}{4} a^4b^2p^2x^{\frac{n}{2}-6} + \frac{1}{2^3} \times n.\frac{n-8}{2}.\frac{n-10}{3}.\frac{n-12}{4}.\frac{n-14}{5}.\frac{n-16}{6} a^6b^3p^3x^{\frac{n}{2}-9} + \frac{1}{2^7} \times n.\frac{n-10}{2}.\frac{n-12}{3}.\frac{n-14}{4}.\frac{n-16}{5}.\frac{n-18}{6}.\frac{n-20}{7}.\frac{n-22}{8} a^8b^4p^4x^{\frac{n}{2}-12} +$ &c.) $= A = a^n p - b^n p^{n-1}$.

Let n be an even number divisible by 3, then will the above-mentioned quantity $A = a^n p - b^n p^{n-1} - 3a^{\frac{2n}{3}} b^{\frac{n}{3}} p^{\frac{n}{3}} + 3a^{\frac{n}{3}} b^{\frac{2n}{3}} p^{\frac{2n}{3}-1}$.

In all the preceding cases n, m and r denote whole affirmative numbers.

These equations may be deduced in the same manner as is before given in Case 3. I; or can be demonstrated by writing in the equation free from radicals for the different powers of x their values deduced from the given equation $x = a\sqrt[r]{p} + b\sqrt[r]{p^2}$.

To

To render the ſolution general, it may not be improper to ſubjoin the ſubſequent.

LEMMA.

1. Let $\alpha, \beta, \gamma, \delta, \epsilon, \zeta$, &c. be the reſpective roots of the equation $z^n - 1 = 0$; then will $\alpha^m + \beta^m + \gamma^m + \delta^m + \epsilon^m +$ &c. $= 0$, unleſs $n = m$, or n is a diviſor of m, in which caſe $\alpha^m + \beta^m + \gamma^m + \delta^m + \epsilon^m +$ &c. $= n$.

2. The ſum of all quantities of the following kind $\alpha^m\beta^r + \alpha^r\beta^m + \alpha^m\gamma^r + \alpha^r\gamma^m + \beta^m\gamma^r + \beta^r\gamma^m + \alpha^m\delta^r +$ &c. will be $= 0$; unleſs n be either equal to, or a diviſor of $m + r$, in which caſe the ſum above-mentioned will be $= -n$; except n be either equal to m or r, or a diviſor of them, in which caſe the ſum will be $n^2 - n$; but if $m = r$, then in the former caſe will the above-mentioned ſum $= -\frac{n}{2}$, and in the latter $= \frac{n^2 - n}{2}$.

3. The ſum of all quantities of this kind $\alpha^m\beta^r\gamma^s\delta^t$ &c. $+ \alpha^r\beta^m\gamma^s\delta^t$ &c. $+ \alpha^m\beta^r\gamma^s\delta^t$ &c. $+ \alpha^r\beta^s\gamma^m\delta^t$ &c. $+$ &c. will be $= 0$, unleſs n be either equal to $r + m + s + t$ &c. or a diviſor of it.

Let π be the number of indices m, r, s, t, &c. and n be either equal to $m + r + s + t$ &c. or a diviſor of it, but n be neither equal to, nor a diviſor of the ſum of any two, three, four, ... $\pi - 3$, $\pi - 2$ or $\pi - 1$ of the above-

mentioned

mentioned quantities; then will the sum above-mentioned $= \mp 1.2.3.4...\overline{\pi-2}.\overline{\pi-1} \times n$; where it will be $+$, if π be an odd number; otherwise $-$.

In this case, if a indices be m, b indices be r, c indices be s, d indices be t, &c. then will the above-mentioned sum $= \mp \frac{1.2.3.4...\overline{\pi-2} \times \overline{\pi-1}}{1.2.3...a \times 1.2.3...b \times 1.2.3...c \times 1.2.3...d \times \&c.} \times n$.

Let n be either equal to, or a divisor of the sum of any number ϱ (less than π) of the above-mentioned quantities m, r, s, t, &c. and consequently either equal to, or a divisor of the sum of the $(\pi-\varrho)$ remaining quantities: find the sum of all possible quantities of this kind $1.2.3..\overline{\varrho-2} \times \overline{\varrho-1} \times 1.2.3..\overline{\pi-\varrho-2} \times \overline{\pi-\varrho-1} \times n^{\circ}$, which sum call A.

Let n be either equal to, or a divisor of the sum of any number (σ) of the above-mentioned quantities m, r, s, t, &c; and also equal to, or a divisor of the sum of any number (ϱ') of the remaining quantities, and consequently it will be either equal to, or a divisor of, the sum of the $(\pi-\varrho'-\sigma)$ remaining quantities; then find the sum of all possible quantities of this sort $1.2.3..\overline{\sigma-2} \times \overline{\sigma-1} \times 1.2.3..\overline{\varrho'-2} \times \overline{\varrho'-1} \times 1.2.3..\overline{\pi-\varrho'-\sigma-2} \times \overline{\pi-\varrho'-\sigma-1} \times n^{3}$, which sum call B.

In the same manner let n be either equal to, or a divisor of the sum of any number (τ) of the above-mentioned

tioned quantities m, r, s, t, &c; and similarly let n be either equal to, or a divisor of the sum of any number (σ) of the remaining quantities; and also let n be either equal to, or a divisor of the sum of any number (ρ) of the remaining quantities; then will n be either equal to, or a divisor of the sum of the $(\pi-\tau-\sigma-\rho'')$ remaining quantities: find the sum of all quantities of this sort $1.2.3..\overline{\tau-2}\times\overline{\tau-1}\times 1.2.3..\overline{\sigma-2}\times\overline{\sigma-1}\times 1.2.3..\overline{\rho''-2}\times\overline{\rho''-1}\times 1.2.3..\overline{\pi-\tau-\sigma-\rho''-2}\times\overline{\pi-\tau-\sigma-\rho''-1}\times n^{\tau}$, which sum call c; and so on; then will the above-mentioned sum $\alpha^{m}\beta^{r}\gamma^{s}\delta^{t}$ &c. $+\alpha^{r}\beta^{m}\gamma^{s}\delta^{t}$ &c. $+\alpha^{m}\beta^{r}\gamma^{s}\delta^{t}$ &c. $+\alpha^{r}\beta^{s}\gamma^{m}\delta^{t}$ &c. + &c. $=\mp(1.2.3..\overline{\pi-2}\times\overline{\pi-1}\times n-A+B-C+D-$ &c.) where it will be + if π be an odd number, otherwise −.

In this case, if a indices be m, b indices be r, c indices be s, d indices be t, &c. then will the above-mentioned sum $=\mp\frac{1.2.3..\overline{\pi-2}\times\overline{\pi-1}.n-A+B-C+D-\&c.}{1.2.3..a\times 1.2.3..b\times 1.2.3..c\times 1.2.3..d\times\&c.}$.

7. Let α, β, γ, δ, ε, &c. be the roots of the equation $x^{n}-1=0$, and the resolution be $x=a\sqrt[n]{p}+b\sqrt[n]{p^{2}}+c\sqrt[n]{p^{3}}+d\sqrt[n]{p^{4}}\ldots\ldots+b\sqrt[n]{p^{\lambda}}\ldots+k\sqrt[n]{p^{\mu}}\ldots\ldots+l\sqrt[n]{p^{\nu}}\ldots+q\sqrt[n]{p^{\xi}}\ldots\ldots+r\sqrt[n]{p^{o}}\ldots\ldots+s\sqrt[n]{p^{n-4}}+t\sqrt[n]{p^{n-3}}+v\sqrt[n]{p^{n-2}}+u\sqrt[n]{p^{n-1}}$; then will the different values of x be respectively $a\sqrt[n]{p}\times\alpha+b\sqrt[n]{p^{2}}\times\alpha^{2}+c\sqrt[n]{p^{3}}\times\alpha^{3}+d\sqrt[n]{p^{4}}\times\alpha^{4}\ldots\ldots+b\sqrt[n]{p^{\lambda}}\times\alpha^{\lambda}\ldots+k\sqrt[n]{p^{\mu}}\times\alpha^{\mu}\ldots\ldots+s\sqrt[n]{p^{n-4}}\times\alpha^{n-4}+t\sqrt[n]{p^{n-3}}\times\alpha^{n-3}+v\sqrt[n]{p^{n-2}}\times\alpha^{n-2}+u\sqrt[n]{p^{n-1}}\times\alpha^{n-1}$;

$a\sqrt$

$a\sqrt[n]{p}\times\beta+b\sqrt[n]{p^2}\times\beta^2+c\sqrt[n]{p^3}\times\beta^3+d\sqrt[n]{p^4}\times\beta^4\ldots+b\sqrt[n]{p^5}\times\beta^5\ldots+k\sqrt[n]{p^n}\times\beta^n\ldots\ldots+s\sqrt[n]{p^{n-4}}\times\beta^{n-4}+t\sqrt[n]{p^{n-3}}\times\beta^{n-3}+v\sqrt[n]{p^{n-2}}\times\beta^{n-2}+u\sqrt[n]{p^{n-1}}\times\beta^{n-1}$;

$a\sqrt[n]{p}\times\gamma+b\sqrt[n]{p^2}\times\gamma^2+c\sqrt[n]{p^3}\times\gamma^3+d\sqrt[n]{p^4}\times\gamma^4\ldots+b\sqrt[n]{p^5}\times\gamma^5\ldots+k\sqrt[n]{p^n}\times\gamma^n\ldots\ldots+s\sqrt[n]{p^{n-4}}\times\gamma^{n-4}+t\sqrt[n]{p^{n-3}}\times\gamma^{n-3}+v\sqrt[n]{p^{n-2}}\times\gamma^{n-2}+u\sqrt[n]{p^{n-1}}\times\gamma^{n-1}$;

$a\sqrt[n]{p}\times\delta+b\sqrt[n]{p^2}\times\delta^2+c\sqrt[n]{p^3}\times\delta^3+d\sqrt[n]{p^4}\times\delta^4\ldots+b\sqrt[n]{p^5}\times\delta^5\ldots+k\sqrt[n]{p^n}\times\delta^n\ldots\ldots+s\sqrt[n]{p^{n-4}}\times\delta^{n-4}+t\sqrt[n]{p^{n-3}}\times\delta^{n-3}+v\sqrt[n]{p^{n-2}}\times\delta^{n-2}+u\sqrt[n]{p^{n-1}}\times\delta^{n-1}$;

&c. &c. &c. &c.

and consequently the sum of the values or roots, which is the coefficient of the second term of the equation sought, will be $a\sqrt[n]{p}\times\overline{\alpha+\beta+\gamma+\delta+\&c.}\,(o)+b\sqrt[n]{p^2}\times\overline{\alpha^2+\beta^2+\gamma^2+\delta^2+\&c.}\,(o)+c\sqrt[n]{p^3}\times\overline{\alpha^3+\beta^3+\gamma^3+\delta^3+\&c.}\,(o)+\ldots+v\sqrt[n]{p^{n-2}}\times\overline{\alpha^{n-2}+\beta^{n-2}+\gamma^{n-2}+\delta^{n-2}+\&c.}\,(o)+u\sqrt[n]{p^{n-1}}\times\overline{\alpha^{n-1}+\beta^{n-1}+\gamma^{n-1}+\delta^{n-1}+\&c.}\,(o)=o$.

The sum of the products of every two of the values or roots, which is the coefficient of the third term of the equation sought, will be $a^2\sqrt[n]{p^2}\times\overline{\alpha\beta+\alpha\gamma+\beta\gamma+\alpha\delta+\beta\delta+\gamma\delta+\&c.}\,(o)+ab\sqrt[n]{p^3}\times\overline{\alpha\beta^2+\beta\alpha^2+\alpha\gamma^2+\gamma\alpha^2+\beta\gamma^2+\gamma\beta^2+\alpha\delta^2+\delta\alpha^2+\&c.}\,(o)$, and in general all the terms will be o, unless $a\times u\times p\times\overline{\alpha\beta^{n-1}+\beta\alpha^{n-1}+\alpha\gamma^{n-1}+\gamma\alpha^{n-1}+\beta\gamma^{n-1}+\gamma\beta$

$\gamma\beta^{n-1}+\alpha\delta^{n-1}+\delta\alpha^{n-1}+\beta\delta^{n-1}+\delta\beta^{n-1}+\gamma\delta^{n-1}+\delta\gamma^{n-1}+$ &c. $(-n)$ $+bv\times pv\times\alpha^2\beta^{n-2}+\beta^2\alpha^{n-2}+\alpha^2\gamma^{n-2}+\gamma^2\alpha^{n-2}+\beta^2\gamma^{n-2}+\gamma^2\beta^{n-2}$ $+\alpha^2\delta^{n-2}+\delta^2\alpha^{n-2}+\beta^2\delta^{n-2}+\delta^2\beta^{n-2}+$ &c. $(-n)+ctp\times$ $\alpha^3\beta^{n-3}+\beta^3\alpha^{n-3}+\alpha^3\gamma^{n-3}+\gamma^3\alpha^{n-3}+\beta^3\gamma^{n-3}+\gamma^3\beta^{n-3}+\alpha^3\beta^{n-3}+$ $\delta^3\alpha^{n-3}+\beta^3\delta^{n-3}+\delta^3\beta^{n-3}+$ &c. $(-n)+dsp\times\alpha^4\beta^{n-4}+\beta^4\alpha^{n-4}+$ $\alpha^4\gamma^{n-4}+\gamma^4\alpha^{n-4}\beta^4\gamma^{n-4}+\gamma^4\beta^{n-4}+$ &c. $(-n)+$ &c. $=-np(au+bv+ct+ds+$ &c.)

If $n=2\lambda$, then will the coefficient of b^2p be $\frac{n}{2}$, i. e. the above-mentioned coefficient will be $-np\,(au+bv+ct+ds+\ldots.+\frac{1}{2}b^2)$.

The sum of the contents of every three of the above-mentioned values or roots, which is the coefficient of the fourth term of the equation required, will be $a^3\sqrt[n]{p^3}\times\alpha\beta\gamma+\alpha\beta\delta+\alpha\gamma\delta+\beta\gamma\delta+$ &c. $(o)+a^2b\sqrt[n]{p^4}\times$ $\alpha\beta\gamma^2+\alpha\gamma\beta^2+\beta\gamma\alpha^2+\alpha\beta\delta^2+$ &c. $(o)+$ &c. $+a^2v\sqrt[n]{p^n}\times$ $\alpha\beta\gamma^{n-2}+\alpha\gamma\beta^{n-2}+\beta\gamma\alpha^{n-2}+\alpha\beta\delta^{n-2}+\alpha\delta\beta^{n-2}+$ &c. $\left(\frac{1.2.n}{1.2}\right)+$ $abt\sqrt[n]{p^n}\times\alpha\beta^2\gamma^{n-3}+\alpha\gamma^2\beta^{n-3}+\beta\alpha^2\gamma^{n-3}+\beta\gamma^2\alpha^{n-3}+\gamma\alpha^2\beta^{n-3}+$ $\gamma\beta^2\alpha^{n-3}+\alpha\beta^2\delta^{n-3}$ &c. $(1.2.n)+$ &c.; and in general all the terms (unless the quantity $\sqrt[n]{p^0}$ contained in the term have this formula $\sqrt[n]{p^n}=p$, or $\sqrt[2n]{p^{2n}}=p^2$) will be $=o$; let the general term be denoted by $blk\sqrt[n]{p^{\lambda+\mu+\nu}}\times$ $\alpha^\lambda\beta^\mu\gamma^\nu+\alpha^\lambda\beta^\nu\gamma^\mu+\alpha^\mu\beta^\lambda\gamma^\nu+\alpha^\mu\beta^\nu\gamma^\lambda+\alpha^\nu\beta^\lambda\gamma^\mu+\alpha^\nu\beta^\mu\delta^\lambda+$ &c. first let $\lambda+\mu+\nu$ neither be equal to n or $2n$, then will the term

term above-mentioned = 0; if it be equal to n or $2n$, then will the term be $1.2 \times n \times bklp$ or $1.2nbklp^2$.

If two of the three indexes λ, μ, ν be equal to each other, then divide the above-mentioned term by 1.2; if the three indexes be equal, i. e. $\lambda=\mu=\nu$, divide it by 1.2.3: find all quantities of this kind where $\lambda+\mu+\nu$ either is equal to n or $2n$, and add all the term from thence derived, and call the sum of them A.

The sum of the contents of every four of the values or roots above-mentioned, which is the coefficient of the fourth term of the equation required, will be $\overline{a^4\sqrt[n]{p^4} \times \alpha\beta\gamma\delta + \alpha\beta\gamma\delta + \&c.}\ (0) + \overline{a^3b\sqrt[n]{p^3} \times \alpha\beta\gamma\delta^2 + \alpha\beta\gamma^2\delta + \alpha\beta^2\gamma\delta + \alpha^2\beta\gamma\delta + \&c.}\ (0) + \&c$: let $bklq\sqrt[n]{p^{\lambda+\mu+\nu+\xi}} \times \overline{\alpha^\lambda\beta^\mu\gamma^\nu\delta^\xi + \alpha^\lambda\beta^\mu\gamma^\xi\delta^\nu + \alpha^\lambda\beta^\nu\gamma^\mu\delta^\xi + \alpha^\lambda\beta^\nu\gamma^\xi\delta^\mu + \alpha^\lambda\beta^\xi\gamma^\mu\delta^\nu + \alpha^\lambda\beta^\xi\gamma^\nu\delta^\mu + \alpha^\mu\beta^\lambda\gamma^\nu\delta^\xi + \&c.}$ denote a general term; this term will be = 0, unless $\lambda+\mu+\nu+\xi$ either $=n$ or $2n$ or $3n$; in which case the term will be either $-1.2.3nbklqp$ or $-1.2.3nbklqp^2$ or $-1.2.3nbklqp^3$; unless $\lambda+\mu=\nu+\xi=n$, when the above-mentioned term will be $-(1.2.3n-n^2)\,bklqp^2$; in this case if $\lambda=\nu$, and consequently $\mu=\xi$, then it will be $-(1.2.3n-1.2n^2)\,bklqp^2$; but if $\lambda=\mu=\nu=\xi=\frac{n}{2}$, then will the term be $-(1.2.3n-3n^2)\,bklqp^2$.

In all these cases, if two of the indexes λ, μ, ν, ξ be equal, then must the term given above be divided by

1.2; if three, by 1.2.3; if four, by 1.2.3.4; and laſtly if two are equal to each other, and the two remaining indexes equal to each other, but not to the former two, then muſt the term aforeſaid be divided by 1.2.1.2.

Find the ſum of all the poſſible terms of this kind, which call B.

In the ſame manner from the preceding Lemma may be found the aggregates of the contents of every five, ſix, ſeven, &c. roots or values multiplied into each other, which call reſpectively C, D, E, &c; then will the equation required be $x^n * - np(au+bv+ct+ds+\&c.)x^{n-2} - Ax^{n-3} + Bx^{n-4} - Cx^{n-5} + Dx^{n-6} - \&c. = 0$.

From the ſame principles may be deduced the moſt general reduction yet known of equations to others of inferior dimenſions, *e. g.*

Let (X) $x^n + (A + a\sqrt[m]{p} + b\sqrt[m]{p^2} + c\sqrt[m]{p^3} + \ldots + s\sqrt[m]{p^{m-2}} + t\sqrt[m]{p^{m-1}})x^{n-1} + (B + a'\sqrt[m]{p} + b'\sqrt[m]{p^2} + \ldots + s'\sqrt[m]{p^{m-2}} + t'\sqrt[m]{p^{m-1}})x^{n-2} + (C + a''\sqrt[m]{p} + b''\sqrt[m]{p^2} + \&c.)x^{n-3} + \&c. = 0$; let α, β, γ, δ, &c. be the reſpective roots of the equation $x^m - 1 = 0$, then, from the principles before given, may be formed the different values of the equation X, which being multiplied into each other from the propoſitions beforementioned of the Meditationes Algebraicæ, may be deduced an equation of *nm* dimenſions free from radicals,

whose root is x, and which contains mn unknown quantities A, a, b, c, &c. B, a', b', c', &c. C, a'', b'', c'', &c. p: for one, two or more of these unknown quantities may be assumed any quantities whatever, and thence may be deduced equations of mn dimensions, which may be reduced to equations $x^n + (A + a\sqrt[n]{p} + b\sqrt[n]{p^2} + c\sqrt[n]{p^3} + \&c.)\, x^{n-1} + \&c. = 0$ of n dimensions.

In the same manner may be assumed equations, which involve $\sqrt[n]{p}$, $\sqrt[n]{p^2}$, ..., $\sqrt[n]{p^{n-1}}$; $\sqrt[r]{Q}$, $\sqrt[r]{Q^2}$, $\sqrt[r]{Q^3}$, ... $\sqrt[r]{Q^{r-1}}$; $\sqrt[t]{T}$, $\sqrt[t]{T^2}$, $\sqrt[t]{T^3}$, ..., $\sqrt[t]{T^{t-1}}$, &c; and from so reducing them as to exterminate the irrational quantities, may often be derived equations whose resolutions or reductions are known.

The method of transforming algebraical equations into others, whose roots bear any assignable algebraical (but not exponential) relation to the roots of a given algebraical equation first published by me in the papers sent to the Royal Society, and afterwards in the year 1760; and thirdly in my Miscellanea Analytica; and lastly in the Meditationes Algebraicæ, and since published by Mr. LE GRANGE in the Berlin Acts, is perhaps (as Mr. LE GRANGE observes) more general than Mr. HUDDE's, or any transformation yet invented; it is very useful in the resolution of numerous problems; and

further

further has this peculiar advantage over all other transformations yet invented, that it often eaſily diſcovers ſome of the firſt terms of the equation required, from which many elegant Theorems may be derived.

In the works above-mentioned, viz. Miſcell. Analyt. Medit. Algeb. &c. are given ſome problems ſerving to this transformation; the firſt of which is a ſeries, which from the coefficients of a given algebraical equation ($x^n - px^{n-1} + qx^{n-2} - \&c. = 0$) finds the ſum of any power of the roots (viz. $\alpha^m + \beta^m + \gamma^m + \delta^m + \&c.$ where α, β, γ, δ, &c. denote the roots of the given equation), the law of which ſeries was publiſhed by me many years before that it was given by Mr. EULER. The third Problem often mentioned in this paper is an elegant and uſeful ſeries for finding the ſum of quantities of the following kind, viz. $\alpha^m\beta^r\gamma^s\delta^t$, &c. $+ \alpha^r\beta^m\gamma^s\delta^t$, &c. $+ \alpha^s\beta^m\gamma^r\delta^t$ &c. $+ \alpha^t\beta^m\gamma^r\delta^s$ &c. $+ \alpha^m\beta^s\gamma^r\delta^t$ &c $+$. &c.

Mr. EULER gave the following reſolution, $x = \sqrt[n]{\pi} + \sqrt[n]{\varrho} + \sqrt[n]{\sigma} + \sqrt[n]{\tau} + \&c.$ where π, ϱ, σ, τ, &c. denote the roots of an equation of $n-1$ dimenſions $v^{n-1} - pv^{n-2} + qv^{n-3} - \&c. = 0$. It is evident, that in this caſe the equation whoſe root is x will have n^{n-1} dimenſions; for let the roots of the equation $z^n - 1 = 0$ be denoted by α, β, γ, δ, &c. then will the quantity $\sqrt[n]{\pi}$ have the n following values

lues $\alpha\sqrt[n]{\pi}$, $\beta\sqrt[n]{\pi}$, $\gamma\sqrt[n]{\pi}$, &c. and the same may be affirmed of the quantities $\sqrt[n]{\varrho}$, $\sqrt[n]{\sigma}$, $\sqrt[n]{\tau}$, &c. and consequently the quantity $\sqrt[n]{\pi}+\sqrt[n]{\varrho}$ will have $n\times n$ different values; and in the same manner the root $x=\sqrt[n]{\pi}+\sqrt[n]{\varrho}+\sqrt[n]{\sigma}+\sqrt[n]{\tau}+$ may be proved to contain $n\times n\times n\times n\times$ &c. $=n^{n-1}$ roots, and consequently in this resolution, in equations of superior dimensions, the number of independent coefficients $(n-1)$ will be very few in proportion to the number of dimensions n^{n-1}, or (if we respect its formula) n^{n-2} of the resulting equation.

Let $n=3$, and the equation resulting will rise to an equation of nine dimensions, which has the formula of a cubic; for let $x=\sqrt[3]{\pi}+\sqrt[3]{\varrho}=a$ one root, then will $\frac{-1+\sqrt{-3}}{2}a$ & $\frac{-1-\sqrt{-3}}{2}a$ be two other of the nine roots, and consequently the roots will be $\overline{x^3-a^3}\times\overline{x^3-b^3}\times\overline{x^3-c^3}=0$, which has the formula of a cubic: and in general the above-mentioned equation of n^{n-1} dimensions will, for the same reason, have the formula of an equation of n^{n-2} dimensions.

Let the resolution be $x=\sqrt[n]{\pi}+\sqrt[n]{\varrho}+\sqrt[n]{\sigma}+\sqrt[n]{\tau}+$ &c. where π, ϱ, σ, τ, &c. denote the roots of an equation $x^{n-1}-px^{n-2}+qx^{n-3}-$ &c. $=0$ of $(n-1)$ dimensions, then will the resulting equation free from radicals, whose root is x, rise to 2^{n-1} dimensions; but as every affirmative

tive has a negative root equal to it, it will have the formula of an equation of 2^{s-1} dimensions.

Let the resolution be of this formula $x = \sqrt[r\times s]{\alpha} + \sqrt[r\times s]{\beta} + \sqrt[r\times s]{\gamma} + \sqrt[r\times s]{\delta}$ &c. if α, β, γ, δ, &c. be considered as the r power of the roots of an equation of s dimensions, then will the resulting equation, of which the resolution is given, rise only to an equation of the formula of m^{s-1} dimensions.

In the year 1762 I published some reasons, for which this method could not extend to the general resolution of algebraical equations.

XI. *Observations on the total (with Duration) and annular Eclipse of the Sun, taken on the 24th of* June, 1778, *on Board the* Espagne, *being the Admiral's Ship of the Fleet of* New Spain, *in the Passage from the* Azores *towards* Cape St. Vincent's. *By Don* Antonio Ulloa, F. R. S. *Commander of the said Squadron; communicated by* Samuel Horsley, *LL.D. F. R. S.*

Read December 24, 1778.

THE public prints will have given notice of my arrival at this port, with the fleet under my command, on the 29th of June last. A very favourable, though

---

Observations de l'Eclipse du Soleil totale avec Retenſion et Annulaire faites le 24e Juin 1778; *ſur le Vaiſſeau* l'Eſpagne *Commandant l'Eſcadre de la Flotte de la* Nouvelle Eſpagne, *en faiſant le trajet des* Iſles Terceres *vers le* Cap St. Vincent. *Par* Don Antonio de Ulloa *chef d'Eſcadre et Commandant General de la ditte Flotte, Membre de la Societé Royale de* Londres.

ON aura appris par les nouvelles publiques, que je ſuis rentré dans ce port le 29e du mois paſſé avec la flotte de la Nouvelle Eſpagne ſous mon commandement. Le trajet dans mon retour, qui a été long mais trés heureux, m'a été favo-

though long, paſſage gave me the opportunity of obſerving at ſea the eclipſe of the Sun, which was accompanied by a phenomenon obſerved by few aſtronomers, and which I myſelf ſaw for the firſt time; to wit, the luminous Annulus which ſurrounds the diſk of the Moon: the following is a deſcription of this appearance, one of the moſt beautiful that can be conceived.

The motion of the ſhip prevented our obſerving the beginning of the eclipſe, by reaſon of the difficulty there was in keeping the Solar image and a part of that of the Moon within the field of the teleſcope; the object vaniſhed every inſtant, and it was not till after ſeveral fruitleſs trials that I could get it again. Beſides this, the arms grew tired of holding up the teleſcope and ſmoaked glaſs, which could not be reſted upon any thing from the neceſſity there was of moving the teleſcope in a contrary

---

rable pour obſerver en mer l'Eclipſe du ſoleil accompagnée d'un phenomene très particulier que j'ai vu, pour la prémiere fois et que peu d' aſtronomes, ont obſervé, juſqu' á préſent? c'eſt l'anneau lumineux autour du diſque de la lune, phenomène des plus frapans et des plus beau à la vue; en voici la deſcription:

Le mouvement du vaiſſeau ne permit pas d'obſerver le commencement de l'eclipſe, par la difficulté de conſerver le corps ſolaire et une partie de celui de la Lune dans le champ de la Lunette; l'objet m'échapoit à tout moment, et je ne le ratrapois qu'après bien des recherches. Outre cela, les bras ſe fatiguoient à ſoutenir en l'air la lunette et le verre obſcur, qu'on ne pouvoit apuyer, parce qu'il falloit

trary direction to that of the ſhip. I had no other calculations but thoſe to be met with in the *Connoiſſance des Tems*, which I did not find very exact, owing either to ſome error in the calculations themſelves, or to the longitude of the ſhip's place not having been accurately determined in that book: I found a pretty ſenſible difference in the hour ſet down for the beginning of the eclipſe. I obſerved the total obſcurity of the Sun's diſk at 44 minutes paſt three, the beginning of the emerſion at 48 minutes after three, the end of the eclipſe at 48 minutes after four; conſequently, the middle of it muſt have been at 46 minutes after three, or thereabouts: the total obſcurity laſted four minutes, a ſufficient time for obſerving the ring which was formed round the Moon.

Five

---

falloit faire avec la Lunette un mouvement contraire à celui du vaiſſeau. Je n'avois d'autres calculs que celui de *la Connoiſſance des Tems* que je ne trouvois pas de la derniére préciſion, ſoit qu'il ſe trouve quelque erreur dans le calcul, ſoit que la longitude eſtimée du lieu ou le vaiſſeau ſetrouvoit ne fuſſe pas la veritable. Je trouvois une difference aſſez ſenſible ſur l'heure indiquée pour ſon commencement; J'obſervai la totale obſcurité du diſque du Soleil à 3 heures 44 min., le commencement de l'emerſion à 3 h. 48 m. la fin de l'eclipſe à 4 h. 48 m. par conſéquent le milieu devoit être à 3 h. 46 m. ou environ. La durée de l'eclipſe totale du Soleil fut de 4 minutes, intervale ſuffiſant pour obſerver l'anneau qui ſe forma autour de la Lune.

Five or ſix ſeconds after the immerſion we began to obſerve round the Moon a very brilliant circle of light, which ſeemed to have a rapid circular motion ſomething ſimilar to that of a rocket turning about its center. This light became livelier and more dazzling in proportion as the center of the Moon approached to that of the Sun, and about the middle of the eclipſe it was of the breadth of about a ſixth of the Moon's diameter. Out of this luminous circle there iſſued forth rays of light, which reached to the diſtance of a diameter of the Moon, ſometimes more, ſometimes leſs, which made me think that they were parts of a weaker light which were reflected in an atmoſphere more ſubtle than that in which the ring was formed. When the centers of the two planets began to ſeparate, the diminution began, and took

---

5 ou 6 ſecondes après que l'immerſion eut été faite on commença à decouvrir autour de la Lune un cercle de lumiére très brillant qui ſembloit avoir un mouvement rapide circulaire, ſemblable a celui d'un artifice embraſé mis en jeu ſur ſon centre. Cette lumiére devint plus vive et plus éblouiſſante à meſure que le centre de la Lune aprochoit de celui du Soleil; et dans le temps que l'eclipſe fut à ſon milieu elle étoit large de deux doigs du diametre de la Lune, ou comme la ſixiéme partie du dit diamètre. De ce cercle lumineux partoient des rayons de lumiére de toute ſa circomférence, perceptibles juſqu' à la diſtance d'un diamètre de la Lune; tantôt plus, tantôt moins, ce qui me fit penſer que cétoit des parties de lumiére plus foibles qui s'imprimoient dans un atmoſphere plus ſubtil que celui ou étoit formé l'anneau. Lorſque les centres des deux planètes commencérent à s'ecarter, la diminution commença et ſe fit graduellement dans le même

took place gradually in the ſame order which had been obſerved at its beginning and during the progreſs of it. It diſappeared entirely four or five ſeconds before the emerſion. The colour of the light was not the ſame every where; the part immediately joining the diſk of the Moon was of a reddiſh caſt, from thence it changed towards a pale yellow, which about the middle began to clear till, at the external extremity, it ended in an almoſt entire white. It was equally brilliant throughout, and the whirling motion, common to all the parts of it, ſeemed to change the form and poſition of the rays which appeared to the eye ſometimes larger, ſometimes ſhorter, at the ſame time that there was no change either in the colours of the ring themſelves, or in the arrangement of them, both which continued as I have deſcribed them.

For

même ordre qui l'étoit obſervé dans ſon commencement et ſes progrès : il diſparut entiérement 4 ou 5 ſecondes avant l'emerſion. La couleur de la lumiére n'etoit pas la même partout : la partie immediate au diſque de la Lune étoit couleur rougeatre, enſuite elle tiroit ſur le jaune pâle; et depuis le milieu juſqu'à l'extrêmité extérieure cette couleur jaune s'éclairciſſoit inſenſiblement juſqu'à tirer en fin tout a fait ſur le blanc. Elle étoit également brillante partout, et ſon mouvement de tourbillon, commun à toutes ſes parties paroiſſoit changer la forme et la poſition des rayons en les préſentant à la vue, tantôt plus courts, tantôt plus longs, ſans cependant occaſionner de changement dans les couleurs de l'anneau et leur arrangement qui reſtoit le même que je viens de détailler.

Quatre

For four or five ſeconds before the appearance of the ſhining ring, and during as many after it had diſappeared, one could ſee the ſtars of the firſt and ſecond magnitude as at the entrance of the night; but when it was in its greateſt degree of brilliancy, only thoſe of the firſt magnitude could be diſcovered. The darkneſs was ſuch, that perſons who were aſleep, and happened to wake, thought that they had ſlept the whole evening, and only waked when the night was pretty far advanced. The fowls, birds, and other animals on board took their uſual poſition for ſleeping as if it had been night.

Before the edge of the Sun's diſk emerged from that of the Moon, there was diſcovered near that of the latter a very ſmall point of that of the Sun; it was imperceptible to the naked eye, but having looked at it with

---

Quatre ou cinq ſecondes avant de voir paroître l'anneau brillant, et autant après ſa ſupreſſion l'on vit, comme à l'entrée de la nuit, les etoiles de la 1ère et de la 2de grandeur; mais lors qu'il étoit dans ſon brillant on ne voyoit que celles de la 1ère. L'obſcurité fut au point que des perſonnes qui dormoient et qui s'eveillérent crurent à leur grand étonnement d'avoir dormi toute la ſoirée et de ne s'être éveillées qu' aſſez avant dans la nuit. Les poules, les oiſeaux et les autres animaux prirent leur poſition ordinaire pour dormir comme ſi c'eut été la nuit.

Avant que le bord du diſque du Soleil parut par celui de la Lune, on decouvrit près de celleci un tres petit point de celui du Soleil imperceptible à la vue; mais l'ayant diſtingué par le ſecours de la lunette, je l'eſtimai d'abord de la grandeur

with the glass I estimated it at first to be about the magnitude of a star of the fourth order; after which it seemed to increase to that of one of the third. Its first appearance, to wit, that before the edge of the Sun emerged from that of the Moon, lasted about a minute and a quarter, the luminous circle was still visible though already much weaker than it had been.

The reddish colour of the ring towards the Lunar disk, its deep yellow towards the middle, its clear and very pale yellow at the external extremity, its uniform circumference, and the rays issuing from it to the distance taken notice of above, convince me that the whole is the effect of the Lunar atmosphere, which is of a substance different from that of the earth, that is, more transparent, more homogeneous, more uniform, and fitter

---

grandeur d'une etoile de la 4e classe; et ensuite il me parut augmenter jusqu'à la grandeur de celles de la 3e. Sa prémiére apparition, c'est à dire avant que le bord du Soleil parut par celui de la Lune, fut de la durée d'environ une minute et un quart: le cercle lumineux subsistoit encore quoique deja affoibli.

La couleur rougeatre de l'anneau proche du disque de la Lune, jaunatre comme couleur d'or vers le milieu, jaune clair et tres affoibli vers sa partie extérieure; sa circonférence egale, et les rayons qui partent de cet anneau à la distance ditte ci dessus persuadent que le tout est l'effet de l'atmosphere de la Lune, laquelle est de matiére differente de celle de la terre; plus transparente, plus nette, plus egale et plus propre à réfléchir les rayons de lumiére que celle ci; autrement, l'anneau n'auroit pas été également clair, brillant et coloré dans la circonference entiére du disque de la lune. On ne peut pas dire que cet anneau lumineux soit l'effet

ter for reflecting the rays of light, ſince otherwiſe the ring would not have been equally clear, ſhining, and coloured throughout the whole circumference of the Lunar diſk. It cannot be ſaid, that this luminous ring is the effect of the rays of the Sun reflected by the atmoſphere of the earth, becauſe the apparent diameter of the Sun is ſmaller than that of the Moon, whoſe diſk entirely hid that of the Sun. Beſides, if the luminous circle had been made by the atmoſphere of the earth, its colours would have been like thoſe of the rainbow, and it would have appeared fixed without motion, inſtead of which, that which was ſeen is the ſame as that which is ſeen by the naked eye upon the Sun when it is juſt above the horizon a little after Sun-riſe or before Sun-ſet, ſo that one may conclude, that this luminous circle is a part of the diſk of the Sun ſeen after refraction through the atmoſphere of the Moon.

The

---

l'effet des rayons du Soleil reflechis ſur l'atmoſphere de la Terre, puiſque le diamêtre apparent du Soleil eſt plus petit que celui de la Lune, dont le diſque cachoit entiérement à nos regard ou à ceux du globe terreſtre celui du Soleil. D'ailleurs, ſi cétoit ſur l'atmoſphere de la Terre que le cercle lumineux fut formé, ce cercle auroit été ſemblable dans ſes couleurs à l'arc-en-ciel, et il auroit paru fixe ſans mouvement; au lieu que celui qui a été aperçu eſt le même qu'on diſtingue dans le Soleil en le regardant directement avec la ſimple vue ſur l'horizon peu après ſon lever ou un peu avant ſon coucher: enſorte qu'on peut conclure que ce cercle lumineux eſt une partie du diſque du Soleil vu par refraction ſur l'atmoſphere de la Lune.

The point of the Sun's disk, which was seen before its limb began to emerge from that of the Moon, is a very extraordinary phenomenon which I was not acquainted with before. In order to obviate all doubts which might arise about it, I must mention that we were three observers, Don JOACHIN D'ARANDA, Lieutenant WINTUYSEN, and I. Mr. D'ARANDA, who was looking at the eclipse through a two-foot telescope about the end of the total obscurity, was the first who perceived it. He, not knowing what it was, told me, that the total obscurity drew near an end, because he discovered a small point of the Sun, like a star, on the edge of the Moon. I looked immediately with the naked eye, and saw nothing. I then took out a spy glass, with which I saw as much. At length I took out my telescope of two feet and a half, and did discover with that a red luminous point so near the

---

Le point du disque du Soleil, vu avant que son limbe eusse commencé à paroitre par celui de la Lune, est un phenomène tres particulier et dont je n'avois pas connoissance. Pour prevenir les doutes qui peuvent se lever je dois dire que nous étions trois personnes à observer l'eclipse: M. M. Don JOACHIN DE ARANDA Cap. de frégate de l'armée, et pilotte major de la flotte; Don P. WINTUISEN lieutenant de vaisseau et major de la ditte flotte, et moi. Mr. D'ARANDA, en regardant l'eclipse vers la fin de la totale obscurité avec sa lunette de deux pieds, fut celui qui l'aperçut le premier: Il me dit, ne sachant ce que c'étoit, que la totale obscurité étoit près de finir, parce qu'il voyoit un petit point du Soleil sur le bord de la Lune semblable à une etoile. Je regardai d'abord avec la vue,

the edge of the Moon, that it left me no doubts of its belonging to the body of the Sun. I, at that time, eſtimated it to be about the ſize of a ſtar of the third magnitude; and imagine, that when Mr. D'ARANDA diſcovered it, it muſt have been like one of the fourth. This point gradually increaſed, and when it became of the bigneſs of a ſtar of the ſecond magnitude, the edge of the Sun emerged from that of the Moon. The interval between the firſt diſcovery of this point and the beginning of the emerſion was about a minute and a quarter. This apparition of the Sun, before the beginning of the emerſion, can only have taken place through ſome crevice or inequality on the limb of the Moon, not perceivable at the full Moon, by reaſon of the reflected rays which croſs each other, and confuſe it; whereas at the time of the eclipſe,

et je n' aperçu rien: Je tirai une lorgnette de la poche et je n'en vis pas d'avantage; enfin je pris ma Lunette de 2½ pieds avec laquelle je découvris effectivement un point rouge et lumineux tres proche du bord de la Lune qui ne me laiſſa aucun doute que ce ne fut le corps du Soleil. Je l'eſtimai pour lors comme une etoile de la 3ᵉ grandeur, et je préſume que lors que M. D' ARANDA la découvrit, elle pouvoit paroitre comme une étoile de la 4ᵉ grandeur. Ce point grandit ſucceſſivement; et lorqu'il pouvoit être jugé comme une etoile de la 2ᵉ grandeur le bord du Soleil parût par celui de la Lune. L'intervale qu'il y eut entre la 1ᵉʳᵉ viſion de ce point et le commencement de l'emerſion fut d'une minute et un quart. Cette apparition du Soleil avant le commencement de l'emerſion ne peut avoir eu lieu qu'a travers de quelque fente ou inégalité qui ſe trouve ſur le limbe de la Lune, et qui eſt imperceptible lors du plenilune à cauſe des rayons reflechis qui ſe croiſent et confondent la ditte ouverture; au lieu que dans le

tems

eclipſe, the Moon's body being entirely obſcured, the light of the Sun is behind, and comes through the ſmalleſt openings in the diſk without any confuſion.

The time elapſed between the firſt appearance of the Sun's body through the aperture of the limb of the Moon and the appearance of the limb of the Sun out of that of the Moon will ſerve to determine the depth of the ſaid chink, aperture, or inequality, which is equal to the height of the eminencies which form it.

The luminous point was towards the North-weſt part of the Moon's diſk, a little more to the North than the part of its limb through which that of the Sun appeared at the beginning of the emerſion; and it is remarkable, that no other luminous ſpeck was perceived in the diſk beſides this. This aperture is therefore the only one in that part of the diſk through which the emerſion was to

---

tems de l'eclipſe le corps de la Lune ſe trouvant entiérement obſcurci, la lumiére du Soleil ſe trouve par derriére et perce ſans confuſion par les plus petites ouvertures du diſque de cet aſtre.

Le tems qui ſ'eſt écoulé depuis la premiére apparition du corps du Soleil par l'ouverture du limbe de la Lune juſqu'à l'apparition du limbe du Soleil par celui de la Lune ſervira à determiner la profondeur de la ditte fente, ouverture, ou inégalité qui eſt égale à la hauteur des éminences qui la forment.

Le dit point lumineux étoit à la partie du Nord-Oueſt du diſque de la Lune, un peu plus au nord de l'endroit de ſon limbe par ou ſe fit voir celui du Soleil au commencement de l'emerſion; et il eſt à remarquer qu'on n'aperçut pas d'autre, point lumineux dans le diſque de la Lune que celui là: ainſi cette ouverture eſt

to begin; from whence one may be certain, that throughout the fourth part of the Moon's circumference, reaching from North to Weſt, there is not any perceptible breaks in its limb beſides that which was then obſerved. There can be no doubt but that the luminous ſpeck which appeared through the aperture was part of the Sun's body; this is demonſtrated, by the red fiery colour (the ſame as that which is ſeen when this luminary is looked at through a ſmoaked glaſs) by its gradual increaſe, in proportion as the limb of the Sun came near that of the Moon, and in ſhort by the colour, which at its emerging was juſt the ſame as that which had been ſeen through the opening.

It remains to be mentioned, that on the 24th day of July, the day on which I made the above obſervation

---

unique dans la partie du diſque par ou devoit commencer l'emerſion, et on peut aſſurer que dans la quatrieme partie de la circonference de la Lune, il n'y a pas dans ſon Limbe, depuis le Nord juſqu'à l'oueſt d'autres fentes perceptibles que celle qui fut obſervée. Il n'y a point de doute que le point lumineux qui parut à travers l'ouverture ne fut le corps du Soleil; Cela eſt démontré par la couleur de feu trés rouge, la même qui ſe voit quand on regarde cet Aſtre à travers d'un verre obſcurci, par la gradation qui eut lieu dans ſon accroiſſement à meſure que le Limbe du Soleil aprochoit de celui de la Lune, et enfin, par la couleur du Soleil, qui lors qu'il deborda fut la même que celle qui s'étoit vue à travers de l'ouverture.

Il me reſte à dire que le 24e Juin, jour que je fis cette obſervation à bord du Vaiſſeau

vation on board the Eſpagne, the aforeſaid ſhip's latitude was 37° 14″ North, meaſured the ſame day; that ſince noon it had ſailed direct Eaſt; that from the end of the eclipſe to its being in the meridian of Cape St. Vincent it had ſailed 301 ſea miles Eaſt, making 100 ſea leagues, reckoning 20 leagues to a degree, remains to be known the difference of meridians of the ſaid Cape and the meridian of the different obſervatories of the capital cities of Europe, in order to determine the part of the ſea in which the obſervation was made relatively to the obſervatories.

The ſolar ſpots were ſeen very diſtinctly both before and after the eclipſe; there were ſix of them in all: two very near each other on the Eaſtern part of the diſk; two towards the middle of the diſk, likewiſe very near one another;

Vaiſſeau l'Eſpagne commandant l'eſcadre de la flotte de Vera Cruz, ce V^au étoit par 37 degrés 14 minutes de Latitude Septentrionale, obſervée le même jour; que depuis le Midy il avoit fait route a l'eſt directement; que depuis la fin de l'Eclipſe juſqu'a être nord ſud avec le Cap St. Vincent il a navigué à l'eſt 301 milles maritimes qui font 100 ⅓ lieues maritimes de 20 au degré; reſte à ſavoir la difference de Méridien entre le dit Cap et les different Obſervatoires des villes capitales de l'Europe, pour determiner l'endroit à la mer ou l'obſervation fut faite relativement aux dits Obſervatoires.

Les taches du Soleil furent vues tres diſtinctement avant et après l'Eclipſe; elles étoient au nombre de ſix: deux à la partie de l'eſt du diſque peu diſtantes l'une de l'autre: deux vers le milieu du diſque auſſi aſſez près l'une de l'autre: et

another; and two towards the North, verging towards the North-weſt.

The corrected altitude of the center of the Sun above the horizon, taken at the moment the eclipſe ended, was 36° 31″. The atmoſphere was very clear; the wind WNW, and not very ſtrong. No clouds were viſible, as is often the caſe at the ſea, nor were there any till near ſix, when there aroſe ſome juſt above the horizon.

The luminous ring made ſo ſtrong an impreſſion on me, as well from the beauty and brightneſs of its colour as from its rapid and uniform circular motion that I could neither reckon the ſtars viſible in each interval from the total obſcurity to the end of the eclipſe, nor make ſeveral other obſervations on the colour and vivacity of their light.

---

et deux enfin vers la partie du Nord un peu vers Nordoueſt.

La hauteur corrigée du centre du Soleil ſur l'horizon, priſe au moment que l'Eclipſe finit étoit 36 degres 31 m. L'atmoſphere étoit très net et l'air de l'Oueſt Nord-Oueſt de moyenne force; on ne voyoit aucun nuage comme cela arrive ſouvent en mer; ce ne fut que vers les ſix heures qu'il ſ'en forma quelques uns ſur l'horizon.

L'anneau lumineux me fit une impreſſion ſi agreable tant par la beauté et l'eclat de ſa couleur que par ſon mouvement circulaire uniforme et rapide que je ne pus ni compter les etoiles viſibles dans chaque intervale depuis la totale obcurité juſqu'á la fin, ni faire d'autres obſervations ſur la couleur et la vivacité de leur lumiére: Je m'attachai uniquement à l'anneau et enſuite au point lumineux

light. All I attended to was, firſt, the ring, and then the luminous ſpeck which appeared through the diſk of the Sun. Theſe made the ſame impreſſion on all who obſerved with me.

It is not eaſy to make celeſtial obſervations at ſea with the ſame preciſion and delicacy as they are made at land, on account of the motion of the ſhip, and want of convenience to uſe the inſtruments. It would have been difficult (even if we had had a Micrometer) to have meaſured either the breadth of the ring, in order to ſee if it was equal every where, or the diſtance between the luminous ſpeck ſeen on the diſk of the Moon and its limb. I regret, however, exceedingly not having been able to make obſervations which would have been of ſuch uſe in aſtronomy.

---

neux du Soleil au travers du diſque de la Lune. Ce raviſſement produiſit le même effet ſur ceux qui obſervoient avec moi.

Il n'eſt pas facile de faire en mer des Obſervations Celeſtes avec autant de préciſion et de delicateſſe qu'on les fait à terre, à cauſe du mouvement du vaiſſeau et de la gène à ſe ſervir des inſtrumens. Il auroit été difficile, quand meme on anroit été pourvu d'un Micromètre, de meſurer la largeur de l'anneau pour examiner ſ'il étoit égal partout, comme auſſi la diſtance du point lumineux vu ſur le diſque de la Lune juſqu'a ſon limbe. J'ai bien du regret de n'avoir pu faire ces obſervations qui auroient été d'un grand avantage pour la Phiſique des aſtres.

XII. *Tentamen continens Theoriam Machinæ ſublicarum.* *Autore* Thoma Bugge, *Aſtronomo Regio, Aſtron. et Mathem. Prof. in Academia* Havnienſi, *e Societatibus Scient.* Havnienſ. *et* Nidroſ. *Communicated by Sir* John Pringle, *Bart. F. R. S.*

Read Dec. 24, 1779.

INTER innumera commoda, quæ ſocietati civili adfert Mechanica, haud minimum eſt ars ſublicas adigendi, ſeu, palos majores trabeſque oblongas terræ impingendi. Artem hanc veteribus non fuiſſe ignotam ex pluribus VITRUVII locis poteſt probari. Etiam ſi celeberrimus hic antiquitatis autor machinam non deſcribat, tamen extra omne dubium poſita eſt veterum in hac arte peritia. Sine ea enim impoſſible fuiſſet exſtruere pontes, molas, aggeres, pyramides, columnas, ædificia, quorum molem, majeſtatem, firmitatemque venerabundi admiramur et vix imitari audemus. Hæc omnia requirunt fortiſſimas et ſolidiſſimas ſubſtructiones. Si loca ſint congeſtitia et paluſtria, ſublicæ machinarum vi adiguntur, tunc imponitur craticula; plures ſublicæ impinguntur, capitibus promi-

prominentibus; earum intercapedines opplentur lapidibus majoribus, ſilicibus, arena majori foſſitia et mortario, quibus fundamentis demum ſuperſtruenda ſunt ædificia.

Formam machinæ, qua veteres architectones ſublicas adegerunt, non ſatis conſtat. Recentiores variis ei dederunt compages et configurationes. Complures deſcripſerunt LEOPOLD, DESAGULIERS, et BELIDOR. Inter has eminet et palmam omnibus præripit ſublicarum machina VAULOUE inventa, a DESAGULIERS deſcripta, ac in uſum perducta dum fundamenta pontis Weſtmonaſterienſis conjicerentur. Præcipua ejus commoda ſunt, ut ad omnis (quod arietem vocare licet) elevandum minor requiratur hominum numerus, ut aries ad majorem elevatus altitudinem libere decidat, utque arietem deciduum luſu machinæ iterum arripiat forceps, et mox elevet; quibus machinamentis breviſſimo temporis ſpatio et pauciſſimis operariis maximus ſublicarum numerus ad maximam profunditatem adigi poſſunt.

Theoriam effectus hujus machinæ quidem dedit BELIDOR. Sed, quantum video, eam ſuperſtruxit fundamento prorſus erroneo et parum ſolido; eam deducit ex regulis colliſionis corporum, conſiderando ſublicam terræ impingendam et onus deciduum tanquam corpora colliſa. Quis autem non vidit regulas colliſionis ſupponere motum liberum, et medium non reſiſtens? Nullo ergo jure

in dato caſu, ubi ſublicæ ſoli reſiſtentia valde magna opponitur, applicari poteſt. Tentabimus aliam explicare hujus machinæ theoriam.

Res eo redit, ut onus ingens ex certa altitudine cadens percutiat ſublicarum capita annulo ferreo cincta; conſiderabimus duas machinas; vocabimus onera cadentia = o et *o*; altitudines, e quibus decidunt = A et *a*; ſublicarum adigendarum maſſas = M et *m*; ſuperficies earum, quoad terræ impactæ ſunt = S et *s*; et profunditates ſublicarum in ſolo = P et *p*. Percurſio oneris cadentis inſtar virium vivarum eſt æſtimanda per productum ex maſſa oneris in quadratum celeritatis; hoc autem quadratum proportionale eſt altitudini, ex qua cadit onus; proinde percurſio æſtimari poteſt per factum ex maſſa oneris impingentis in altitudinem computatam a ſupremo puncto ad caput ſublicæ. Sed effectus ſunt uti vires cauſarum ſuarum plenæ. Ergo, ſi reſiſtentiam ſoli et maſſas ſublicarum utrobique æquales ſtatuamus, profunditates, ad quas ſingulis percurſionibus adiguntur ſublicæ, erunt in ratione compoſita è rationibus directis onerum et altitudinum; ſeu

$$p : P = a \times o : A \times O.$$

Si ſumamus cohærentiam ſoli æqualem et homogeneam, reſiſtentia, quam, dum ſubſident, vincere debent ſublicæ, creſcit in ratione ſuperficierum ſolo impactarum. Si

jam

jam ſtatuamus onera cadentia æqualia $o = o$; altitudines quoque æquales $A = a$; patet effectus percuſſionum et hinc profunditates decreſcere prout creſcunt tam ſuperficies adactæ quam ſublicarum pondera vel maſſæ. Hinc ſub data hypotheſi, erunt profunditates in ratione compoſita e rationibus inverſis ſuperficierum et maſſarum, ſeu

$$p : P = s \times M : f \times m = \frac{1}{f \times m} : \frac{1}{s \times M}.$$

Si jam omnia ſunt inæqualia, nempe onera cadentia, altitudines, maſſæ ſublicarum, et earum ſuperficies in terra conditæ; dico profunditates, ſingulo ictu acquiſitas, eſſe in ratione compoſita e rationibus directis onerum cadentium et altitudinum, et e rationibus inverſis ſuperficierum et maſſarum. Concipiamus tertiam ſublicam, cujus maſſa $= M$, ſuperficies adacta $= s$; onus impingens $= o$; altitudo, e qua cadit onus $= a$; dicatur profunditas hujus ſublicæ ex data percurſione proveniens $= \pi$. Tunc erit per antea demonſtrata

$$p : \pi = \frac{1}{m \times f} : \frac{1}{M \times s}.$$

$$\pi : P = a \times o : A \times O.$$

Ergo $p : P = \frac{a \times s}{m \times f} : \frac{A \times O}{M \times s}$.

Hæc theoremata inſerviunt diverſis ſublicarum machinis comparandis, praxique exercendæ. Ad determinandum

ſumtus operis exſtruendi maxima ſunt utilia, iiſque ſuperſtruimus ſequens problema:

Calculo definire profunditatem, ad quam ſingulo ictu ſubſidet ſublica data machinæ vi adacta.

Cum in hoc caſu tam onus cadens quam maſſa pali impingendi conſtans ſit et æqualis; erit $o = o$, et $M = m$. Hinc explicata proportio fundamentalis in ſequentem abit.

$$p : P = \frac{a}{i} : \frac{A}{s}.$$

Porro ſuperficies ſublicarum terræ inpactarum ſunt rectangula eandem baſin ſed diverſam altitudinem p et P habentia (P hic ſignificat profunditatem totalem). Quapropter $i : s = p : P$, id quod ſimpliciorem et commodiorem ſubminiſtrat analogiam:

$$p : P = \frac{a}{i} : \frac{A}{P}.$$

Poſt percurſiones quaſdam factas, adeo ut firmiter terræ inhæreat ſublica, fiat denique novus ictus, quem pro primo numeramus, tum cadat onus ex altitudine $= a$ et ſubſideat ſublica profunditate $= p$. Fiat tum ſecundus ictus, tunc ſubſidebit palus profunditate $= x$. Onus cadet per altitudinem $A = a + p$, et ſublicæ profunditas totalis erit $= P = p + x$. Facta jam debita ſubſtitutione, habemus,

$$p : x = \frac{a}{p} : \frac{a+p}{p+x}.$$

Ex

Ex qua analogia originem ducit ſequens æquatio.

$$px+x^2=p^2+\frac{p^2}{2}.$$

Quæ æquatio quadratica, ſi reſolvatur, dabit valorem incognitæ

$$x=\pm\sqrt{\tfrac{5}{4}p^2+\tfrac{p}{2}}-\tfrac{1}{2}p.$$

Applicemus calculum ad datum exemplum. Sit altitudo, e qua decidit onus percutiens $a=3$ ped $=36$ pol. Profunditas ad quam primo ictu ſubſidet fublica $=p=4$ pol. dicatur jam profunditas ad quam ſecundo ictu ſubſidebit $=x$; erit:

$$4:x=\tfrac{36}{4}:\tfrac{40}{4+x}$$

$$4x+x^2=\tfrac{160}{9}$$

$$x=2\tfrac{1}{3}\text{ pol.}$$

Secundo ictu ſublica ſubſidet numero rotundo $\frac{1}{3}$ pol. In tertio ictu erit altitudo, quam percurrit onus impingens $=36+4+3=43$ pol. Profunditas fublicæ $=4+3=7$ pol. Denique profunditas tertio ictu acquiſita $=x$; tunc,

$$4:x=\tfrac{36}{4}:\tfrac{43}{7+x}$$

$$7x+x^2=\tfrac{172}{9}$$

$$x=\tfrac{11}{7}+\tfrac{1}{2}=2\text{ pol. quam proxime.}$$

In quarto ictu eſt altitudo $=36+4+3+2=45$ pol. et profunditas fublicæ $=4+3+2=9$ pol. Profunditas quarto ictu acquiſita $=x$; tunc erit,

$$4:x$$

$$4 : x = \frac{36}{4} : \frac{45}{9+x}$$

$$9x + x^2 = \frac{180}{9}$$

$$x = \frac{12}{2} - \frac{9}{2} = 1\frac{1}{2} \text{ pol. quam proxime.}$$

Idem problema ſibi ſolvendum ſumſit D. RELIDOR. Supponit ſublicam primo ictu ſubſidere 15 pol. Tunc juxta ejus calculos ſecundo ictu ſubſidebit 17; tertio 19; quarto 21; quinto 23. Quis autem non vidit hanc progreſſionem cum theoria et experientia pugnare? Profunditas enim ſingulo ictu acquiſita continuo decreſcit, et tandem ſublica repetitis ictibus non amplius ſubſidet. Id quod evenit, quando cohærentia ſoli et frictio major eſt vi a percurſione oriunda. Eo in caſu ſublica profundius adigi non poteſt niſi augeantur vel onus percutiens vel altitudo, e qua cadit.

In actis Academiæ Stockholmienſis mechanicus quidam haud incelebris ſtatuit ſublicam ponderibus oneratam in hoc caſu ulterius et profundius in terram adigi poſſe. Verum ſi ſublica ita oneratur, idem eſt ac ſi ſublicæ maſſa major eſſet, quod non auget ſed impedit effectum percurſionis. Ad adigendam ſublicam pondus impoſitum agit ſola preſſione, quæ pro inſenſibili eſt habenda reſpectu reſiſtentiæ et frictionis. Si vero onus impingens augeatur, certiſſime quoque augebitur percuſſio. Quam rem theoria et experientia confirmant; notum

enim

enim eſt ex experimentis D. CAMUS malleum 12 librarum ambabus manibus elevatum et proinde ex altitudine 5 pedum cadentem eundem effectum reddere ac ſimplex preſſio 1000 librarum.

Determinare maximam profunditatem, ad quam fublica data machina datâ adigi poteſt.

Sit altitudo, quam onus percurrit in primo ictu $= a$; profunditas per primum ictum acquiſita $= p$; poſt factas complures percuſſiones ſublica ſubſidet quantitate admodum parva $= m$; et tum operæ pretium non eſt plures dare percuſſiones. Profunditas totalis antea acquiſita $= x$; et altitudo, quam onus percutiens deſcribit $= a + x$. Hinc,

$$p : m = \frac{a}{p} : \frac{a+x}{x}.$$

Ex reſolutione hujus æquationis invenitur,

$$x = \frac{ap}{am - p}.$$

Sit $p = 4$ pol.; $m = \frac{1}{10}$ pol.; $a = 36$ pol.; invenitur maxima profunditas $x = \frac{36 \times 16}{11 - 16} = -576 : \frac{124}{10} = -46{,}6$ pol. Hæc quantitas negativa eſſe debet, cum oppoſita ſit altitudini, quæ inſtar poſitivæ eſt aſſumpta.

Corodinis loco ſequentes practicas obſervationes adjungimus. 1. Pondus oneris impingentis ut plurimum eſt 800 libr. Vis hominis onus continuo labore elevantis

vantus circiter 40 lib. æſtimanda eſt. Hinc in machina ſimplici 20 homines onus elevare valent. Ictibus autem 25 vel 30 datis, ut per æquate temporis ſpatium requieſcant neceſſe eſt. 2. Ad percuſſiones 30 dandas et requiem capiendam 4 minuta prima requiruntur, adeo ut per integram horam 450 ictibus ſublicam percutere liceat. 3. Virium impedimentum eſt, ſi diameter trochleæ ſuperioris, cui funis onus elevans circumvolvitur ſit juſto minor. 4. Si onus impingens ope manuum et non mediante axi in peritrochio eſt elevandum, altitudo, quam percurrit onus, non ſuperare poteſt 5 pedes quos ſolummodo emetiri poſſunt homines brachiorum libero motu. 5. Quando plures adigendæ ſunt ſublicæ, prodeſt opus incipere a mediâ, et ad extremitates procedere, ſi enim contrario modo rem aggreſſus fueris, ſublicæ intermediæ adigi non poſſunt ſine opere et temporis diſpendio propter ſoli compactionem. 6. Antequam opus incipiatur, terra eſt examinanda et ſublica probatoria adigenda, ut exactam de ſoli qualitate ejuſque ſtratis habeas cognitionem. 7. His præſuppoſitis, æſtimari poſſunt ſumtus ad feriem ſublicarum adigendam neceſſarii. Ad machinam transferendam et ſingulas ſublicas perpendiculariter erigendas requiruntur 15 minuta prima. Ex ictibus probatoriis juxta precedentia

pro-

problemata calculari poſſunt numerus percuſſionum per ſingula ſtrata et hinc tempus totum requiſitum. Tandem ex longitudine operis, ex pretio et numero ſublicarum æſtimari poſſunt ſumtus omnes quos impendere oportet.

Havniæ, 30 Auguſti 1778.

XIII. *Account of an Iconantidiptic Teleſcope, invented by Mr.* Jeaurat, *of the Academy of Sciences of Paris. Communicated by* John Hyacinth de Magellans, *F. R. S.*

Read January 15, 1778.

MR. JEAURAT, of the Royal Academy of Sciences of Paris, having diſcovered a conſtruction of the Iconantidiptic Teleſcope, thought proper to communicate to the Royal Society of London a ſhort deſcription of this new invention.

This Teleſcope is called the Iconantidiptic Heliometer, becauſe it produces two images of the objects, the one in a direct poſition, and the other reverſed. Theſe two images,

---

Conſtruction d'une lunette Iconantidyptique inventée par Mr. Jeaurat, *de l'Academie Royale des Sciences de* Paris.

M. JEAURAT, de l'Academie Royale de Paris, ayant imaginé une conſtruction de lunette Iconantidyptique, croit devoir communiquer à la Societé Royale de Londres l'expoſition ſuccinte de cette nouvelle invention.

La lunette eſt appellée Heliom tre Iconantidyptique parce qu'elle repreſente deux images des objets, l'une dans une ſituation droite et l'autre dans une ſituation

images, of oppoſite ſituation to each other, are exactly of the ſame ſize, and produce the effect of ſhewing the ſtars as entering at once both on the right and left ſides of the Teleſcope. The firſt coincidence of the two images on the ſide of each other gives the paſſage of the firſt limb; the exact coincidence of the two images upon one another gives the paſſage of the center of the ſtar; and the laſt coincidence of the two images at the ſide of each other gives the paſſage of the ſecond edge: from whence it follows, that we not only obſerve as uſual the paſſage of the two ſides of the diſk of a ſtar, but alſo the direct paſſage of the center of the ſtar: an obſervation which could not before be made in a direct manner. Beſides, it may obſerved, that this invention obviates the difficulty of illuminating the threads of the Teleſcope in obſerving very

---

tion renverſée. Ces deux images de ſituation oppoſée l'une à l'autre ſont exactement de la même grandeur et produiſent l'effet de voir tout à la fois entrer les aſtres par la droite et par la gauche de la lunette. La premiere coincidence des deux images à coté l'une de l'autre donne le paſſage du premier bord, la coincidence exacte des deux images l'une ſur l'autre donne le paſſage du centre de l'aſtre, et la derniere coincidence des deux images l'une à coté de l'autre donne le paſſage du ſecond bord, d'où il ſuit que non ſeulement on obſerve comme à l'ordinaire le paſſage des deux bord du diſque d'un aſtre, mais auſſi le paſſage direct du centre de l'aſtre: obſervation qui n'a juſq'à preſent pû ſe faire d'une maniere directe. D'ailleurs on remarquera que cette invention ſupplée à la difficulté d'éclairer les fils de la lunette lorſqu'il eſt queſtion d'obſerver de très petites etoiles, car avec cette

very ſmall ſtars, for in this conſtruction there is no occaſion to ſee the threads.

The following is the conſtruction of this Iconantidiptic Teleſcope, which I have already made uſe of, and which appears to be proper for obſervations made in the plane of the Meridian.

That the ſolution may be applicable to Teleſcopes, it is proper that AD=AZ, $aB=aZ$.

Then put AD=F the focal diſtance of the lens A,

$aB=f$ the focal diſtance of the lens a,

$aA=F-f$,

$AB=aA-aB=F-2f$,

BC

---

conſtruction on n'a pas beſoin de voir les fils.

Voici la conſtruction de cette lunette Iconantidyptique dont je me ſuis déja ſervie et qui me paroit commode pour les obſervation faites dans le plan du Meridien.

Pour que la ſolution ſoit auſſi appliquable aux oculaires il convient que AD=AZ, $aB=aZ$.

Alors on ſera AD=F foyer de la lentille A,

$aB=f$ foyer de la lentille a,

$aA=F-f$,

$AB=aA-aB=F-2f$,

BC$=x$,

CD$=y$,

ϕ the focal diſtance of the lens C.

Hence $\begin{cases} \text{BD}=\text{AD}+\text{AB}=2\times\overline{\text{F}-f}, \\ \text{BD}=\text{BC}+\text{CD}=x+y. \end{cases}$

The two values of BD evidently give, 1ſt, $x+y=2\times\overline{\text{F}-f}$.

That the image B, given by the lens a, be ſeen at the diſtance BC: and that the direction of the ray BHD may form a relative focus in D, whoſe diſtance may be equivalent to AD, it is neceſſary that $a\text{B}\times\text{CD}=\text{AD}\times\text{BC}$, namely, 2dly, $fy=\text{F}x$.

That the object B, ſeen in the direction BH, may form a focus in D, it is neceſſary that the focal diſtance of the lens.

BC$=x$,

CD$=y$,

ϕ foyer de la lentille C.

$\begin{cases} \text{BD}=\text{AD}+\text{AB}=2(\text{F}-f), \\ \text{BD}=\text{BC}+\text{CD}=x+y. \end{cases}$

Les deux valeurs de BD donnent evidement, 1°, $x+y=2(\text{F}-f)$.

Pour que l'image B, donnée par la lentille a, ſoit vue à la diſtance BC: et pour que la direction du raion BHD forme un foyer relatif en D, dont le foyer equivalent ſoit AD; il faut (voyez l'optique de SMITH de la Traduction de l'Abbé ROCHON, p. 278. art. 245.) dis-je que $a\text{B}\times\text{CD}=\text{AD}\times\text{BC}$ ſavoir, 2°, $fy=\text{F}x$.

Pour que l'objet B vû ſelon la direction BH, forme un foyer en D, il faut que la

lens c (namely, the distance ϕ) have this condition, $\phi \times BD = BC \times CD$, *viz.* 3dly, $2\phi \times \overline{F-f} = xy$.

From these three conditions, *viz.* $\left\{\begin{array}{ll} 1^\circ & x+y=2\times\overline{F-f}, \\ 2^\circ & fy=Fx, \\ 3^\circ & 2\phi\times\overline{F-f}=xy, \end{array}\right.$ we easily and incontestably find what follows:

$BC=x=\frac{2f\times\overline{F-f}}{F+f}$ the dist. from the focus B to the lens CH,

$CD=y=\frac{2F\times\overline{F-f}}{F+f}$ the dist. of the relative focus D, with respect to the two lenses *a* and c,

$\phi=\frac{2Ff\times\overline{F-f}}{\overline{F+f}^2}$ the focal distance of the lens c.

This solution just found is general; but to adapt it to a particular case, which may be proper for practice, I shall investigate what relation ought to take place between the distances F and *f* when ϕ is $=f$. This supposition

---

le foyer de la lentille c (savoir le foyer ϕ) ait cette condition ci $\phi \times BD = BC \times CD$ savoir, 3°, $2\phi(F-f)=xy$.

Avec ces trois conditions, savoir, $\left\{\begin{array}{ll} 1^\circ & x+y=2(F-f), \\ 2^\circ & fy=Fx, \\ 3^\circ & 2\phi(F-f)=xy, \end{array}\right.$ on trouve facile et inconteſtablement ce qui ſuit.

$BC=x=\frac{2f(F-f)}{F+f}$ diſtance du foyer B à la lentille CH.

$CD=y=\frac{2F(F-f)}{F+f}$ le foyer relatif D, à l'égard des deux lentilles *a* et c.

$\phi=\frac{2Ff(F-f)}{(F+f)^2}$ foyer de la lentille c.

Cette ſolution qu'on vient de trouver eſt generale. Mais afin d'adopter un cas particulier, qui ſoit commode à pratiquer, je vais chercher les rapports, que doivent

ſition gives $\varphi = \frac{2Ff \times \overline{F-f}}{\overline{F-f}^2} = f$; from which we eaſily and inconteſtably extract the relation ſought, *videlicet*, $F = \sqrt{5+2} \times f$; or this, which comes to the ſame thing, $f = (\sqrt{5-2}) \times F$.

But $\left\{\begin{matrix}\sqrt{5}+2=4,2361\\ \sqrt{5}-2=0,2361\end{matrix}\right.$ Therefore for the caſe in which $\varphi = f$, we have $\left\{\begin{matrix}F=4,2361\,f\\ f=0,2361\,F\end{matrix}\right.$ The relation of the focal diſt.

The

---

doivent avoir entre eux les foyers F et f dans le cas où l'on auroit $\varphi = f$. Cette ſuppoſition donne $\varphi = \frac{2Ff(F-f)}{(F+f)^2} = f$; d'où l'on tire facilement et inconteſtament le rapport cherché que voici $F = (\sqrt{5}+2)f$; ou bien celui ci qui revient au même que le precedent $f = (\sqrt{5}-2)F$.

Mais $\left\{\begin{matrix}\sqrt{5}+2=4,2361\\ \sqrt{5}-2=0,2361\end{matrix}\right.$ donc pour les cas où $\varphi = f$, on a $\left\{\begin{matrix}F=4,2361\,f\\ f=0,2361\,F\end{matrix}\right.$ rapport des foyers.

Application

The Application of the general Formula to the particular caſe of the equal lenſes a *and* c.

Let AD = F, the focal diſtance of the lens A,

The relation $f = 0,2361$ F, found for the focal diſtances, gives

- $aB = f = 0,2361$ F, the focal diſt. of the lenſes *a* and c,
- $aA = F - f = 0,7639$ F, the diſt. between theſe lenſes,
- $AB = F - 2f = 0,5278$ F, diſtance,
- $BD = 2 \times \overline{F - f} = 1,5278$ F, diſtance,
- $BC = \frac{2f \times \overline{F - f}}{F + f} = 0,2918$ F, diſtance,
- $CD = \frac{2F \times \overline{F - f}}{F + f} = 1,2360$ F, diſtance.

The

Application de la formule generale au cas particulier des lentilles egales a *and* c.

Soit AD = F, foyer de la lentille A,

Le rapport trouvé des foyers $f = 0,2361$ F, donne

- $aB = f = 0,2361$ F, foyer des lentilles *a* and c.
- $aA = F - f = 0,7639$ F, diſtance entre ces lentilles,
- $AB = F - 2f = 0,5278$ F, diſtance,
- $BD = 2(F - f) = 1,5728$ F, diſtance,
- $BC = \frac{2f(F - f)}{F + f} = 0,2918$ F, diſtance,
- $CD = \frac{2F(F - f)}{F + f} = 1,2360$ F, diſtance.

Application

The numerical application of the particular caſe of the equal lenſes a *and* c.

		Ft.	In.
Let	AD=F=1728 lines, =	12	0
Then we ſhall have	aB=0,23618 F=408 lines,	2	10
	AB=0,52788 F=912 lines,	6	4
	aA=0,76398 F=1320 lines,	9	2
	aD=aB+BD=1,76398 F=3048 lines,	21	2

It is from this particular caſe, in which $\phi=f$, and $f=F\times\sqrt{5-2}=0,23607\ F$, that the following table is conſtructed.

Application numerique du cas particulier des lentilles égales a *et* c.

		P.	P.
Soit	AD = F = 1728 lignes =	12	0
Alors on aura	aB = 0,23618 F = 408 lignes,	2	10
	AB = 0,52788 F = 912 lignes,	6	4
	aA = 0,76398 F = 1320 lignes,	9	2
	aD = aB + BD = 1,76398 F = 3048 lignes,	21	2

C'eſt d'après ce cas particulier, où l'on ſuppoſe $\phi=f$, et que $f=F(\sqrt{5}-2)=0,23607\ F$, qu'eſt conſtruite la table qui ſuit.

Focal distance of the lens A and the equivalent AD.	Focal distances of the lenses a and c, and distance cA from the 2d lens c to the third A.	Distance ac from the first lens a to the second c.	Distance aA from the first lens a to third A.	Whole distance aD.	Distance cD from the 2d lens c to the focus D.
Fr. ft. In.	Fr. ft. In Lin.	Fr. ft. In. Lin.	Fr. ft. In. Lin.	Fr. ft. In. Lin.	Fr. ft. In. Lin.
0 1	0 0 3	0 0 6	0 0 9	0 1 9	0 1 3
0 2	0 0 6	0 1 1	0 1 6	0 3 6	0 2 6
0 3	0 0 8	0 1 7	0 2 3	0 5 3	0 3 8½
0 4	0 0 11	0 2 1	0 3 1	0 7 1	0 4 11
0 5	0 1 2	0 2 8	0 3 10	0 8 10	0 6 2
0 6	0 1 5	0 3 2	0 4 7	0 10 7	0 7 5
0 7	0 1 8	0 3 8	0 5 4	1 0 4	0 8 8
0 8	0 1 11	0 4 3	0 6 1	1 2 1	0 9 11
0 9	0 2 1½	0 4 9	0 6 10½	1 3 10½	0 11 1
0 10	0 2 4½	0 5 3	0 7 8	1 5 8	1 0 4
0 11	0 2 7	0 5 10	0 8 5	1 7 5	1 1 7
1 0	0 2 10	0 6 4	0 9 2	1 9 2	1 2 10
2 0	0 5 8	1 0 8	1 6 4	3 6 4	2 5 8
3 0	0 8 6	1 7 0	2 3 6	5 3 6	3 8 6
4 0	0 11 4	2 1 4	3 0 8	7 0 8	4 11 4
5 0	1 2 2	2 7 8	3 9 10	8 9 10	6 2 2
6 0	1 5 0	3 2 0	4 7 0	10 7 0	7 5 0
7 0	1 7 10	3 8 4	5 4 2	12 4 2	8 7 10
8 0	1 10 8	4 2 8	6 1 4	14 1 4	9 10 8
9 0	2 1 6	4 9 0	6 10 6	15 10 6	11 1 6
10 0	2 4 4	5 3 4	7 7 8	17 7 8	12 4 4
11 0	2 7 2	5 9 8	8 4 10	19 4 10	13 7 2
12 0	2 10 0	6 4 0	9 2 0	21 2 0	14 10 0

XIV. *Account of the Organs of Speech of the* Orang Outang. *By* Peter Camper, *M. D. late Profeſſor of Anatomy, &c. in the Univerſity of* Groningen, *and F. R. S. in a Letter to Sir* John Pringle, *F. R. S.*

Read January 7, 1779.

Klein-Lankum, near Franequer, Dec. 2, 1778.

SIR,

BEING lately informed by Dr. POEMMERING, whom on account of his ſingular induſtry and talents I have recommended to your favour, that you, as well as l'Abbé FONTANA and Dr. INGENHOUSZ, were ſurprized to hear from M. FEBRONI, the keeper of the Duke of Tuſcany's Muſeum, that I had diſcovered the true organical reaſon for which the Orang Outang, and ſeveral other apes and monkies, are unable to ſpeak; I take the liberty of addreſſing to you this anatomical eſſay upon the organ of ſpeech of the Orang Outang and other monkies, in hopes you will judge it worthy to be read to the Royal Society; in whoſe moſt valuable Tranſactions I ſhould be very proud to ſee theſe obſervations; the rather, as it is the firſt eſſay I have offered to that reſpectable body.

It is this diſcovery (of which I have already given a hint at the end of my Obſervations on the Rein-Deer) which Profeſſor ALLAMAND has inſerted amongſt his additions to the XVth volume of the Count DE BUFFON's Nat. Hiſt. printed at Amſterdam 1771, for S. H. SCHNEIDER, p. 55, 56. Profeſſor ALLAMAND has moreover added, in the ſame volume, p. 76: *M. le Prof.* CAMPER *a obſervé les organes de la voix de l'Orang; il s'eſt convaincu qu'il étoit impoſſible, qu'il formât des tons articulés, comme les hommes en peuvent former*, &c.

It is aſſerted by a great many travellers, that though the Orang Outang does not ſpeak, he would be able to articulate if he choſe it. Several Naturaliſts ſeem to leave this queſtion undetermined, from not having had the opportunity of diſſecting this very uncommon animal; others again overlook it, being deeply engaged in the reſearches of other parts.

My principal ſtudy in this eſſay will be to prove the abſolute impoſſibility there is for the Orang and other monkies to ſpeak.

§ 1. Being Profeſſor of Natural Philoſophy, Anatomy, Surgery, and Phyſic, in the Univerſity of Franeker in Frieſland, I ſoon perceived the impoſſibility of underſtanding the moſt precious and valuable works of the immortal GALEN (eſpecially his anatomical works) without

without diſſecting monkies, to compare his exact deſcriptions with. I got for that purpoſe, in the year 1754, a Cynocephalus, and was charmed to find the exactneſs of almoſt all GALEN's deſcriptions. The organ of ſpeech puzzled me, nevertheleſs, very much, and I was not able to explain his obſervations, ſo as to ſatisfy myſelf in this animal: I was obliged, therefore, for want of other apes, to delay my reſearches to another opportunity, which, however, I did not meet with till I came to Amſterdam, where I ſettled in the year 1755.

I diſcovered, at the beginning of 1757, in another Cynocephalus, that the baſis of the *os hyoides* was very large and hollow; and that a membranous bag, lying under the *latiſſimi colli* (which touch one another in the middle of the neck in theſe animals) went up into this bony cavity, having a communication with the inſide of the *larynx* by a hole at the root of the *epiglottis*.

The ſtructure of theſe and the Orang will be better underſtood by the four figures engraved after my own drawings for the anatomy of the Orang. I intend to publiſh them with that of the Rhinoceros with the double horn, and the Rein-Deer.

In the Cynocephalus I found the whole organ of voice pretty much like that of dogs, except the pouch *d*, *n*, *o*, *i*, fig. 4. Examining the root of the *epiglottis* I found a hole

hole *i*, *p*, fig. 3. being the real orifice of the bag *d*, *i*, *o*, *n*, fig. 4.

As all this lies above the *rima glottidis i*, fig. 3. or *i*, *b*, fig. 4. I concluded, that the voice, having paſſed the *glottis*, entered this membranous bag, *d*, *n*, *o*, *i*, by which the neck ſwelled, and out of which the air was forced by the contraction of the *latiſſimi colli*. I had often obſerved this ſwelling in ſome living apes, but now found out the reaſon of it, and was perſuaded of the incapacity of this animal to modulate his voice ſo as to articulate words.

I then conſidered this remarkable paſſage of GALEN'S, de Uſu Part. Ed. Charter. tom. IV. lib. 7. cap. XI. p. 461. *Foramen in utraque lingulæ* (epiglottidis) *parte unum effecit natura, et foramini ipſi parte interna ventriculum ſuppoſuit non parvum. In quem quum aer vias nactus amplas in animal ingreditur, rurſuſque exit, nihil in ventrem depellitur*; and what he, p. 466. further obſerves, *fiſſuram potius, quam foramen eſſe*.

When I compared this with the organ in the Cynocephali, fig. 3, 4. I was at a loſs how to explain GALEN; for I could by no means apply thoſe *ventriculi*, by which he ſeemed to have underſtood large capacities, to the ſmall holes *b*, *i*, *k*, fig. 4. above the *rima glottidis i*, *b*, which, though much larger in the Cynocephali than in

men, could not be applied to this very particular definition of no ſmall bags, *ventriculum non parvum*.

In November 1758 I diſſected another monkey, in which the membranous bag, *d*, *n*, *o*, was much larger, ſo as to occupy almoſt the whole fore part of the neck, under the *latiſſimi colli*.

In the *Apella* (the 29th ſpecies of LINNÆUS, Syſt. Nat. ed. XII. p. 42. or *ſimia caudata imberbis, cauda ſubprehenſili, corpore fuſco, pedibus nigris*) was no ſuch a bag at all, nor any opening at the root of the *epiglottis*, which was entirely ſimilar to that of dogs. I cannot forbear to mention, that in this monkey the *meatus*, or the *proceſſus peritonæi*, were cloſed as in men. This I diſſected in the year 1768, when I was Profeſſor in the Univerſity of Groningen.

Here I got the opportunity, the year following, of diſſecting two *papiones* or *ſphinges* of LINNÆUS, *ſimiæ ſemi caudatæ ore vibriſſato unguibus acuminatis*, ſpec. 6. p. 35. a male and a female; in which the *epiglottis* was likewiſe perforated, the *os hyoides* as in the former, but the pouch very ſmall in compariſon of the apes, who were very large.

As theſe parts are ſo apparent in a great many monkies, and likewiſe in the ape or *Pithecos*, I was very much ſurprized EUSTACHIUS did not diſcover them, eſpecially as

as he had taken great pains to purſue the anatomical doctrine of GALEN, as appears in the XLIſt plate, where he has given ſeveral figures of this organ. I was no leſs ſurprized that ALBINUS and MARTINS did not find this bag; and I wondered likewiſe very much, how Mr. D'AUBENTON, who has had the greateſt opportunity of any anatomiſt, could paſs over ſo ſtriking a conſtruction of this organ. I do not mention RIOLANUS, FALLOPIUS, GORTER, SYLVIUS, BLASIUS, and ſome others, becauſe they had fixed their attention upon quite different parts.

§. 2. As GALEN not only diſſected the *Cebi*, or the Cynocephalus, who are all of the tailed or *caudati* kind, but the *Pithecos* or ape without a tail; and as the celebrated Dr. TYSON had found the organ of voice ſo ſimilar to that of men in his *Pigmy*, I endeavoured to get one from the Eaſt Indies. For this purpoſe I offered a good ſum of money to my correſpondents to have a well-preſerved Orang Outang, becauſe none were to be met with in any collection of Natural Hiſtory in Holland.

I ſoon got a female one in the year 1770, by the kindneſs and generoſity of Dr. HOFFMAN, phyſician at Batavia, formerly my pupil; and the year 1771 another, by favour of Mr. HOPE, Director of the Eaſt India Company of Amſterdam, and Repreſentative of his Moſt Serene Highneſs the Prince of Orange in the ſame Company,

who was ſo good as to order not only a female, but a male one for my uſe; but this laſt was unluckily loſt, with the whole ſhip, betwixt Java and the Cape of Good Hope.

Theſe and the ſucceeding years were very favourable to Naturaliſts; for Profeſſor ALLAMAND got a male Orang for the Muſeum of the Univerſity of Leyden; Mr. VANDER MEULEN, a great admirer of natural hiſtory (who has one of the fineſt collections at Amſterdam) received one, and Mr. VOSMAER got two for the celebrated collection of the Prince of Orange, all females. In the year 1777, Dr. VAN HOEY (a phyſician of great celebrity at the Hague, who has a very rich collection of natural curioſities) got a male (but a very young) Orang. Upon the whole, I had an opportunity of ſeeing ſeven Orangs, beſides the living one, which was ſent to his Highneſs the Prince of Orange.

All theſe reſembled perfectly in ſhape and colour that of Mr. EDWARDS, which is ſtill preſerved in the Britiſh Muſeum.

Seven of thoſe, I had ſeen, had no nails upon the great toes of the feet: it ſurprized me, therefore, to ſee them ſo diſtinctly repreſented by Profeſſor ALLAMAND. I took the liberty to inform him of it; he corrected his deſcription accordingly, p. 75. *ib. in fine*, which was eaſily

done, as the sheets were not worked off at the press. I wrote likewise to Dr. KOOYSTRA, physician to the London Infirmary, to inquire about the Orang in the British Museum. The late Dr. MATY examined, at my request, the Orang with him; and both declared, that not a single mark of a nail was to be found upon the large toes of that specimen, though Mr. EDWARDS had represented them on his 213th table so very large. These two instances shew us, how little we can depend upon figures, if not drawn with great exactness.

The want of these nails, and of the second phalanx of the large toes, is beyond any doubt a very remarkable character in this animal. Nature, however, seems to be inconstant sometimes; for, upon the great toe of the right foot of the Orang in Dr. VAN HOEY's collection, there was a little nail and two phalanges. The singular red, long hair, and the shortness of the neck, form another very peculiar property; for in the living, as well as in all the rest, I have observed the shoulders to rise up to the ears; the lower and upper jaws were much projected forwards, as I shall shew in the anatomical description of the Orang. The country they all came from was Borneo, from which island they are first sent over to Java, and so to Holland by the Cape of Good Hope.

The

The Orang Outangs described by TULPIUS and TYSON, came from Angola, and had both black hair, and large nails upon the great toes. I own the figures of these great men are very deficient in many respects: but, upon the whole, the animals are represented and described as very strong and muscular; whereas all the Orangs from Borneo, I have seen, were the contrary, and had long and very lean arms and legs.

To conclude, it seems very probable, that Africa furnishes a peculiar sort of apes which are not the *Pithecos* of the ancients, though these are not uncommon in Angola.

The organs of voice of the Angolese Orang, dissected by TYSON, are very different from those of the *Pithecos* which I dissected 1777. This one had the *os hyoides* like all the *papiones* or *sphinges*, &c.; the *epiglottis* perforated as in fig. 3. and 4. and therefore different from GALEN's description, and from TYSON's, who makes no mention at all of the one, nor of the two bags which GALEN describes, and which I found in the real Orang of Borneo; not only in one specimen, but in five, which I have dissected for that purpose.

To return to GALEN; I am very apt to think that he dissected an Asiatic Orang, from whom he took his description of the ventricles *a latere linguæ*, at the sides of the *epiglottis*; at least that he dissected such an organ, for

the bones of the *carpus* do not entirely agree with his deſcription, though he ſeems to have been very exact and nice in his diſſections. And indeed I wondered as often as I compared the ſtructure of the *carpus* and *tarſus* of apes, monkies, and dogs, with GALEN's *oſteological* performances upon this ſubject: for though he deſcribes but eight bones in the *carpus*, he mentions the ninth, which I have met with in all monkies, apes, and dogs, and likewiſe in the Orang. The tenth is not eaſily ſeen, it being very much attached to the *os naviculare*. Theſe bones I ſhall give the explanation of in the anatomical deſcription of the Orang.

In the Angoleſe Orang, Dr. TYSON met with the vermicular proceſs of the *inteſt. cæcum*, which I found very conſiderable in the Aſiatic; but of which GALEN appears not to have had the leaſt notion. Mr. D'AUBENTON has given the deſcription and figure of the ſame little gut in the Gibbon, a ſpecies approaching to that of the Orang, and likewiſe an inhabitant of Aſia, but alſo unknown to GALEN.

§ 3. I ſhall now proceed to the organ of ſpeech itſelf, and deſcribe it as it appeared in the firſt Orang I diſſected in October 1770. And for the clearer underſtanding I ſhall add ſome figures to it; firſt, of the fore-part;

ſecondly, of the *larynx* from the inſide of the *pharynx*; and, laſtly, of the inſide of the *larynx* itſelf.

Fig. 2. N, O, P, repreſents the *os hyoides*; N, O, the baſis; P the left *cornu*; N, O, the little graniform bones.

Q, T, U, the *thyroid* cartilage; V the *aſpera arteria*.

Z, X the right ventricle cut open; R, S the left.

Y the hole leading into the bag. The ventricles form here a kind *meatus*, paſſing over the brim of the *thyroid* cartilage, under the *os hyoides*, towards the inſide, where they form the fiſſures *a*, *b*, and *a*, *i*, fig. 5. I diſſected this in the Anatomical Theatre of the Univerſity at Groningen in public.

In a ſecond, which Mr. VOSMAER, the keeper of the Prince of Orange's cabinet, was ſo kind as to grant me for diſſection, I found both theſe ventricles the ſame in every reſpect as the others, except that theſe laſt were of equal ſize.

In the third, which I diſſected at the houſe of Dr. VAN HOEY at the Hague, the 31ſt of Auguſt, 1777, the two ventricles were ſmaller but of equal ſize on both ſides. The animal was very young. The doctor preſerves this preparation in his muſeum.

In a fourth, which I preſerve intire in my collection, but whoſe organ of voice I examined the 30th of November

vember laſt, I found both the ventricles united ſo as to form but one.

The 6th figure gives a ſketch of it; *a*, *c*, *d*, *e*, *f*, *g*, *b*, *b*, is the ventricle, having, nevertheleſs, the two *meatus's* *a* and *b*, and ſhewing evidently a kind of diviſion in *i*; *g*, *b*, making a ſmaller bag.

This bag deſcended downwards to the middle of the breaſt bone, and ſpread itſelf ſidewards over the *ſternomaſtoideus*, with appendices underneath the *cucullares*.

The *latiſſimi colli* adhered very much to the fore-part, but ſidewards; and under, from the muſcles of the neck, they were eaſily ſeparated by tearing gently, either with the top of the finger, or with the flat part of the handle of a diſſecting knife.

As this Orang was much larger than the former ones, and conſequently older, I dare not venture to determine, whether theſe ventricles or bags, which touch each other in the middle, grow together, ſo as to make but one bladder; or whether this may be a variety: becauſe in the Orang which was alive at the Hague, and the hiſtory of which I ſhall give by and by, there was likewiſe but one bag ſtill larger than theſe, and proceeding far over the *clavicles*, backwards under the *cucullares*, and before down two-thirds of the breaſt bone.

This accidental union can probably make no eſſential variety; for as theſe receptacles of air do not ſeem to ſerve for any modulation of voice, they will anſwer their proper purpoſe, whether united into one, or divided into two cavities. We very often ſee the kidnies united at the lower ends acroſs the ſpine in men, without its occaſioning any diſturbance in the ſecretion or animal economy.

§ 4. I muſt now give the hiſtory of the ſo much celebrated Orang which belonged to the Prince of Orange, and died in January 1777. This was a female; when alive the head was always deep in the ſhoulders, and the animal ſeldom lifted it very high up. The man who took care of her obſerved a great quantity of air under the ſkin of the neck on both ſides, which (being ignorant of theſe ventricles) he took for a dangerous diſorder, and the ſymptoms of approaching death. I felt the neck myſelf in December 1776, and diſcovered the bags to be much larger than any I had diſſected. I could remove the air eaſily with my hand from one ſide to the other, and divide it, as it were, into two parts. The bags appeared ſometimes very turgid, ſometimes collapſed.

She died not long afterwards, and was ſoon cut to pieces by the order of Mr. VOSMAER, to be ſtuffed for the Muſeum of his Serene Highneſs the Prince of Orange; but, as this cannot be done without preſerving the face, a part of the ſkull, hands, and feet, it is very evident, that Mr. VOSMAER

was

was obliged to cut off the head and the other extremities, and to destroy the most interesting parts for natural knowledge.

I was very sorry to hear the fate of this curious and uncommon creature, more especially as I had great reason to flatter myself with the dissection of the entire animal as soon as it was dead.

I need not remind any one of the particulars mentioned by Mr. FORSTER in the 2d volume of a Voyage round the World, p. 553.; nor of his rather too severe criticism upon the conduct of Mr. VOSMAER, the inspector of the Museum belonging to the hereditary Stadholder of the United Provinces. Mr. VOSMAER had, without doubt, no other intention but to preserve the fresh skin of this uncommon animal stuffed, for the cabinet of his benefactor, and not the least malevolent intention to prevent the dissection of the other parts not necessary for this purpose: for, when, by a special order of his Most Serene Highness the Prince of Orange, the remaining trunk was sent to me, I found the organ of voice not in the least hurt, and quite entire, as it is still to my great satisfaction. After having duly examined, dissected, and delineated the *viscera* of the breast and belly, I have put it in melasses, in a fine phial, in order to preserve so valuable a preparation, not only for my museum, but for natural knowledge in general.

There

There was no difference betwixt this organ and that I delineated in the 6th figure, but in extent. The united ventricles covered the greateſt part of the breaſt bone, and had ſeveral appendices, which inſinuated themſelves into all the interſtices of the muſcles of the neck and ſhoulders.

It had likewiſe two diſtinct *meatus's* coming from the inſide of the organ at the ſides of the *epiglottis*, as in fig. 5. and paſſing between the *os hyoides* and *thyroid* cartilage.

A large and vermicular proceſs was attached to the *cæcum*; but the inteſtines were very different on the inſide from thoſe of men. The *os femoris* was kept in its ſocket only by a ſtrong capſular ligament, there being no *ligamentum teres*: I had not obſerved one in the Orang which I preſerve, and whoſe feet I diſſected, to compare them with GALEN and others.

§ 5. Having given the ſtructure of the organ of voice in five different Orangs, and demonſtrated their conformity in every other reſpect but the union I mentioned in ſome, I ſhall proceed now to the internal part of the organ, as it is deſcribed by GALEN.

Fig. 5. ſhews the inſide of the organ, which is repreſented in fig. 2. conſequently of the ſame Orang.

d, e, f, is the *epiglottis* or *lingula*.

g, *b*, *k*, *l*, the *cricoid* cartilage, divided in the middle, and expanded sidewards.

b, *d*, *h*, and *g*, *i*, *f*, the *arytenoid* cartilages.

i, *a*, and *a*, *b*, the holes or fissures at each side of the *epiglottis*; *b* and *i*, the cords which form the *rima glottidis*. All this answers exactly to the description given by GALEN.

The air which is forced by expiration out of the lungs, and passes with an accelerated velocity the *rima glottidis*, *b*, *i*, being stopped by the hollow *epiglottis* and the roof of the mouth, narrow nostrils, &c. rushes into these ventricles z, x and q, r, s fig. 2. or into the united large ventricle *a*, *b*, *d*, *e*, *f*, *g*, fig. 6. These are, as GALEN rightly observes, seemingly within the animal; for they are covered with the external integuments and the *latissimi colli*. From thence, or out of these ventricles, the air gets out again by the same fissures *a*, *i*, *a*, *b*, fig. 5. through the mouth and nostrils, without entering into the lungs again, or, as he expresses it, without entering into the belly of the animal, *rursusque exit, nihil in ventrem depellitur*; by *venter* is to be understood the inside of the body.

If this organ does not answer entirely to the description of GALEN, I do not know how to explain the quotation; for there is no animal, as yet known, whose organ

of

of ſpeech is more applicable to it, at leaſt none of the monkey kind, as I obſerved before.

It is hardly to be conceived, how Dr. TYSON ſhould have overlooked all this, and have pronounced the organ of voice of his pigmy to be exactly like that of men, as he has done p. 51.; and yet, it is not impoſſible, when we conſider that he has overlooked other and more ſtriking differences in his eſſay.

Nor is it probable that GALEN ſhould have overlooked the large vermicular proceſs of the *cæcum* and other things, if he had diſſected the ſame kind of African Orang as TYSON did, unleſs he diſſected the Organ of voice in the one, neglecting the inteſtines, and again the bones of the feet in another, as is often the caſe with anatomiſts, as I know by my own experience. This, however, ſeems probable, that GALEN diſſected more than one ſpecies of *pithecos* or apes without a tail, and that even that ſpecies was different from the Angoleſe pigmy and from the Orang of Borneo.

§ 6. Having diſſected the whole organ of voice in the Orang, in apes, and ſeveral monkies, I have a right to conclude, that Orangs and apes are not made to modulate the voice like men: for the air paſſing by the *rima glottidis* is immediately loſt in the ventricles or ventricle of the neck, as in apes and monkies, and muſt conſe-

quently return from thence without any force and melody within the throat and mouth of these creatures: and this seems to me the most evident proof of the incapacity of Orangs, apes, and monkies, to utter any modulated voice, as indeed they never have been observed to do.

I have already mentioned in the anatomical description of the Rein-Deer (p. 55. of Mr. ALLAMAND's addition to the XVth volume of the Count DE BUFFON) the surprizing analogy of its organ of voice with that of the *Pithèci* and *Cercopithèci*. That of the Orang seems to have some analogy with that of frogs, whose voice, however, can be better modulated by their tongues. I have given a description of them in the Memoirs of the Society of Rotterdam. As I am afraid of having dwelt already too long on this subject, I shall here finish this essay; but promise to send the Society an account of the very extraordinary organ of voice of the *alouate* or *hurleur de Cayenne*, the *Simia Capucina* of LINNÆUS, *n.* 30. p. 42. the organ and *os hyoides* of which, &c. I dissected some time ago with all possible care and attention.

I am, &c.

EXPLA-

EXPLANATION OF THE FIGURES.

Fig. 1. repreſents the *pharynx* of the Orang Outang, from which the organs of voice, fig. 2. and 5. are delineated.

A, D, B, C, the tongue from behind.

D, B, C, M, the *palatum molle*, on the back part of which the *uvula* B, L is ſeen.

B, E, G, H, F, the *pharynx*, divided lengthways in the middle from E to G.

K, M, J, the paſſage from the mouth into the *œſophagus* S, K, G, H. Within this is ſeen the *epiglottis* and the *glottis* ſhut by the *arytenoid* cartilages.

Fig. 2. is the ſame organ of voice from the fore-part.

N, O, P, the *os hyoides*; N and O the little graniform bones; P, the left *cornu*.

Q, T, U, the *thyroid* cartilage; V the *aſpera arteria*.

R, S, the left ventricle intire.

W the right, cut open to ſee the orifice of the duct Y from the bag.

Fig. 3. The back part of the tongue and the *glottis* of a monkey.

a, *b*,

a, *b*, the *epiglottis*; *a*, *b*, *r*, *g*, the root and back part of the tongue; *c*, *s*, *t*, *d*, the *œsophagus* laid open.

u, the *aspera arteria*.

f, *e*, the *capitella* of the *arytenoid* cartilages.

e, the upper part or top of the little cartilage between the *arytenoid* cartilage and the *epiglottis*, which I have likewise met with in men, but less prominent.

i, *f*, the *rima glottidis*.

p, *i*, the hole at the root of the *epiglottis*.

Fig. 4. the inside of the *larynx* in profil.

a, *b*, *c*, *d*, the *epiglottis*; *e*, the cartilage mentioned in fig. 3.

f, *b*, the *arytenoid* cartilage; *f*, *g*, the *capitellums* forming a kind of crooked hook.

i, *m*, the cord of the *glottis*.

i, *k*, *h*, the lateral *sinus* above the *rima glottidis*, forming a pretty large ventricle in these animals.

i, *m*, *l*, the *cricoid* cartilage.

d, *n*, *o*, the ventricle, into which the air, coming through the hole at the root of the *epiglottis*, enters.

Fig. 5. the same *larynx*, represented in fig. 1. opened, to see the inward parts.

a, the union of the cords forming the *rima glottidis*.

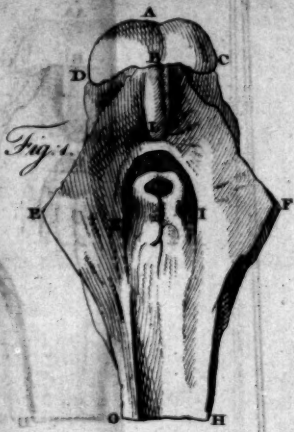


Fig: 1.

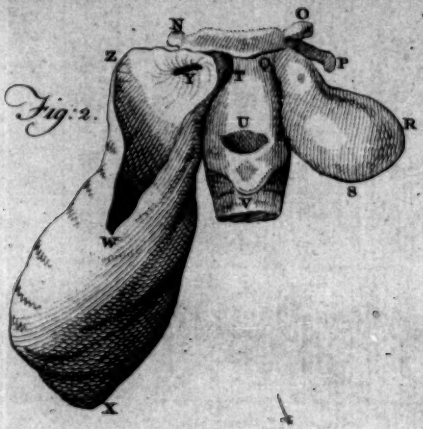


Fig: 2.

Fig: 3.

Fig: 4.

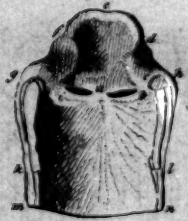


Fig: 5.

T. CAMPICA. DEL.

Fig. 6.

a, *b*, *a*, *i*, the holes or orifices by which the air enters into the two ventricles R, S and Z, X, fig. 2.

b, *c*, *b*, *d*, the right *arytenoid* cartilage, with its *capitellum d*.

i, *g*, *f*, the left *arytenoid* cartilage.

f, *e*, *d*, the *epiglottis*.

g, *b*, *k*, *l*, the *cricoid* cartilage, divided and dilated.

k, *m*, *n*, *l*, the wind-pipe.

Fig. 6. the fore part of the Orang, which I preſerve entire in my muſeum. The ſkin of the neck and the *latiſſimi colli* are laid open, to ſhew the ventricles, &c.

A, B, C, the lower jaw-bone; A, D, A, E, the *genio hyoides*.

F, G, the *cornua* of the *os hyoides*.

H, I, the *thyroid* cartilage; K, the *cricoid*.

L, M, the ſub-maxillary glands.

a, *c*, *d*, *e*, *f*, *g*, *b*, *b*, the large bladder formed by the union of the two ventricles, of which *i*, *f*, is a mark.

a and *b*, the two *meatus's* entering towards the inſide of the *larynx*, betwixt the *thyroid* cartilage and the *os hyoides*.

XV. *Account of the Effects of Lightning on Board the* Atlas. *By* Allen Cooper, *Eſq. Maſter of the* Atlas *Eaſt India-man. In a Letter to* Joſeph Banks, *Eſq. P. R. S.*

Read January 19, 1779.

DEAR SIR, Mother-Bank, Jan. 4, 1779.

AS I am deſirous of acquainting you with every obſervation made either by my friend Dr. LIND or myſelf during the voyage, I cannot help troubling you with an account of the melancholy effects of the lightning on board my ſhip the Atlas on the 31ſt of Dec. 1778. The morning and forenoon of that day were clear and cold, with a ſtrong dry wind from the N.W. which by Dr. LIND's wind-gage generally ſuſtained a column of water of two inches (*a*), and was ſo high as to prevent boats coming off to the ſhip. At 3 P.M. a ſquall from the N.N.W. came with a violence ſcarcely credible, attended with very heavy rain, large hail, and the moſt ſevere lightning, which ſtruck our main-maſt-head, deſcended down the maſt or its rigging, and entered the gun-deck ſomewhere nigh the main hatchway. Thoſe

(*a*) A force equal to lb. 10,4.

who were employed in letting down the ſheet cable (as we had then brought both our anchors a-head) received very ſmart ſhocks, and were witneſſes to the fire going out at ſeveral parts of the ſhip, and to an exploſion equal to that of a well-charged cannon, accompanied with a moſt ſulphureous ſmell which laſted all that day and night. It was not till the ſquall abated that our attention was called to the maſts, when we ſaw one of our beſt ſeamen hanging by his feet in the main catharpins ſtruck dead; another in the main-top was ſo miſerably ſcorched as to remain ſenſeleſs, and now continues in a dangerous way. The boatſwain's mate, who was nigh him, had his arm ſo much hurt by the ſhock he received, as not to recover the uſe of it for half an hour. All poſſible means were uſed to ſave the poor fellow who had received the fatal ſtroke; but there appeared no ſigns of returning life in him. His face was quite livid; and from the livid colour of the ſcorched places it appeared the lightning had entered his head, come out again on the left ſide of his neck, and ſpread itſelf down his left ſide and over his legs. The other man was ſtruck down in the main-top, his back much ſcorched, and on the inſide of his right leg the ſtocking burſt open a little below the knee. I have ſent the cloaths of the man who ſuffered, as alſo the ſtocking of the other man. Our top-gallant-maſts, at

the time they were ſtruck, had no iron work upon them[b]. Upon a careful examination, no viſible track of the lightning could be found upon the maſts, or any part over which it had paſſed, nor was any damage done to the ſhip, maſts, or rigging.

(b) On account of the ſeaſon of the year, in which lightning is ſo extremely unuſual, it had not been thought neceſſary to fix the conductor.

XVI. *Extracts of Three Letters from* John Longfield, *M. D. at* Corke *in* Ireland, *to the Aſtronomer Royal, containing ſome Aſtronomical Obſervations; together with the Longitude of* Corke, *deduced from the ſaid Obſervations, by the Aſtronomer Royal.*

Read February 11, 1779.

SIR, Corke, Oct. 1, 1773.

ENCOURAGED by Mr. WALSH, with whom I have the pleaſure of being acquainted, and who has favoured me with a letter to you; and being confident of your inclination to promote Geography and Aſtronomy; I trouble you with a few obſervations, and requeſt your advice and aſſiſtance in the proſecution of my favourite ſtudy.

Laſt year I built a very ſolid and commodious, though ſmall obſervatory, cloſe to my houſe. The top of one of the hills which ſurround this city would have been a more eligible ſituation; but as my profeſſion confines me to the town I had no choice. To make up its deficiency in height, I have adapted the upper part of my houſe to the

ſame purpoſe, which ſerves very well for inſtruments that do not require great ſolidity: From hence I have a very extenſive view all round. In the obſervatory is a ſolid pier, ſunk deep in the ground, on the top of which ſtands the tranſit inſtrument. It is of tin, three feet and a half long, and made by Mr. MONK. The other inſtruments I have are the following:

An equal altitude inſtrument.

A quadrant of one foot radius, by Mr. BIRD.

Another of two feet and a half radius, of the French conſtruction, not a bad one with regard to the diviſions, but inconvenient.

An excellent teleſcope, with a treble object-glaſs, by Mr. DOLLOND. It magnifies about 140 times, and is of the lateſt improvement.

A parallactic inſtrument, with a common teleſcope five feet long, and a *reticule rhomboide*.

Two aſtronomical clocks, with wooden pendulums, one of which goes full as well as Mr. WOOLLASTON's. The alterations in their going ſeem to be owing to moiſture. I conſtantly compare them with SMEATON's hygrometer.

With the aſſiſtance of a particular friend, who is an excellent mathematician and a very good obſerver [Mr. ELIAS MAINADUC], I have taken a great number of meridian

meridian altitudes of the Sun, and of ſtars to the North and South of the zenith. The mean of both quadrants makes the latitude 51° 53′ 54″.

		App. time. h	′	″	
1772, July	4 at	12	52	0	4's 2d ſat. imm. hazy.
	18 -	12	41	23	1ſt ſat. imm.
Aug.	3 -	10	58	27	ditto, ditto.
Sept.	20 -	8	21	16	ditto, emerſ.
Oct.	6 -	6	46	12	ditto, ditto, hazy.

They were all obſerved with the greateſt magnifying power.

The weather has been almoſt continually cloudy for theſe ſix months paſt, which has prevented me from making any obſervation of conſequence except on April, 29th, an occultation of 1 α Cancri by the Moon at 11h 23′ 25″ apparent time, and an immerſion of Jupiter's firſt ſatellite at 12h 52′ 29″ on Auguſt the 22d.

I ſhould be much obliged to you for the correſponding obſervations to the above, if it would not be too much trouble.

I am, &c.

SIR,

SIR, Corke, Feb. 18, 1774.

I HAVE now had a full trial of SMEATON's hygrometer, and think it a very uſeful and agreeable inſtrument. It is capable of a conſiderable degree of exactneſs, but not ſufficient for any thing which requires great accuracy. It abſorbs the moiſture of the air much more readily than it parts with it; and I have great reaſon to believe, that, as the gravity of the air differs, it will point to different degrees on the ſcale, the degree of moiſture or dryneſs being the ſame. If the cord is too much twiſted it will require frequent adjuſtments, and I know that the extreme degree of moiſture is very uncertain (though that of dryneſs is not ſo) and different perſons will adjuſt it very differently at that point.

My teleſcope I have found, by theory and experiment, to magnify 134 times.

My friend, whom I mentioned to you, has been making obſervations for theſe thirty years. He has a good clock, with a common pendulum; a quadrant of two feet radius; a five feet teleſcope of two glaſſes, with a common micrometer; an excellent reflector of SHORT's, of eighteen inches focus; and is getting a tranſit inſtrument. His obſervations

observations gave him the latitude of Corke 51° 54′, and the longitude 34½ minutes of time West of Greenwich.

I am, &c.

1773	Clock differs from mean Time.	Gains or loses *per diem.*	Mean of Therm. in obs.	Mean of Hygr.	Observations.
	′ ″				
Sept. 11	−0 17.0		60	54	Hygr. was put into the observ. clock was losing 0.5 *per diem.*
12	−0 17.0	−0.0	60	50	
13	−0 17.5	−0.5	60	38	
14			60	36	
15	−0 18.5	−0.5	60	30	
16			60	26	
17			60	20	
18	−0 20.0	−0.5	60	16	
19			60	14	
20			60	18	
21			60	14	
22	−0 21.0	−0.25	55	14	
23			53	20	
24			60	35	
25			60	42	
26			60	35	
27			58	25	
28			58	33	
29	−0 27.0	−0.8	54	32	
30			55	32	
Oct. 1	−0 28.7	−0.8	55	40	
2			53	28	

1773	Clock differs from mean time.	Gains or loses *per diem*.	Mean of Therm. in obs.	Mean of Hygr.	Observations.
	′ ″				
Oct. 3			48	30	Hygrometer adjusted, much lengthened.
4			48	28	
5			50	20	
6	−0 33.0	−0.8	53	22	
7			50	24	
8	−0 35.0	−1.0	55	25	
9			54	22	
10	−0 37.0	−1.0	54	20	
11			53	25	
12	−0 39.0	−1.0	53	14	
13			50	15	
14			54	18	
15			50	20	
16			53	16	
17			54	18	
18			54	18	
19	−0 49.5	−1.5	54	20	
20			53	30	
21			54	42	
22			54	38	
23			53	30	
24	−0 56.5	−1.4	54	25	
25			53	24	
26			54	20	
27			56	18	
28			54	20	Hygrometer adjusted.
29			45	24	

1773	Clock differs from mean time.	Gains or loses *per diem.*	Mean of Therm. in obs.	Mean of Hygr.	Observations.
	′ ″				
Oct. 30	−1 2.5	−1.0	45	30	
31			45	36	
Nov. 1			46	40	
2			45	30	
3			45	32	
4			44	38	
5			45	35	
6			44	40	
7	−0 59.0	+0.4	48	48	
8			46	49	
9			46	59	
10			44	44	
11	−0 58.5	+0.1	44	38	
12			43	34	Hygr. adjusted, had lengthened 1° only.
13	−0 58.0	+0.2	46	37	
14			45	40	
15	−0 58.0	+0.0	46	34	
16			44	39	
17	−0 57.0	+0.5	42	36	
18			40	30	
19			41	28	
20	−0 55.5	+0.5	41	28	
21			45	30	
22	−0 54.5	+0.5	36	31	
23			35	32	
24	−0 52.7	+0.9	38	29	

1773	Clock differs from mean time.	Gains or loses *per diem.*	Mean of Therm. in obs.	Mean of Hygr.	Observations.
	′ ″				
Nov. 25			36	28	
26	−0 51.0	+0.9	40	29	
27			43	48	
28			46	40	
29			40	33	
30	−0 49.0	+0.5	43	32	
Dec. 1	−0 48.5	+0.25	45	34	
2			47	36	
3			46	37	
4	−0 48.0	+0.1	42	32	
5	−0 47.5	+0.5	38	30	
6			40	32	
7			38	29	
8	−0 44.5	+1.0	38	29	
9			38	30	
10			45	48	
11			38	43	
12			44	45	
13	−0 39.5	+1.0	46	30	
14			48	37	
15			47	44	
16			47	42	
17			47	42	
18			47	42	
19			46		
20	−0 31.5	+1.1	48		

1773	Clock differs from mean time.	Gains or loses *per diem.*	Mean of Therm. in obs.	Mean of Hygr.	Observations.
	′ ″				
Dec. 21			50		
22			42		
23	−0 27.5	+1.3	39		
24	−0 26.0	+1.5	36		
25	−0 24.5	+1.5	34		
26			37		
27			40		
28	−0 18.5	+2.0	36		
29			37		
30	−0 15.0	+1.7	34		
31	−0 13.0	+2.0	36		
1774					
Jan. 1			36		
2	−0 8.4	+2.3	32		
3			30		
4	−0 3.8	+2.3	36		
5	−0 2.0	+1.8	42		
6			43		
7			40		
8			46		
9			42		
10			41		
11			40		
12			44		
13			45		
14	+0 7.0	+1.0	43		
15			46		

1774	Clock differs from mean time.	Gains or loses *per diem*.	Mean of Therm. in ob.	Mean of Hygr.	Observations.
	′ ″				
Jan. 16	+0 9.0	+1.0	48		
17			45		
18			32		
19			39	39	
20			43	45	
21			43	45	
22			43	49	
23	+0 18.5	+1.3	38	37	
24			35	30	
25			35	36	
26			42	33	
27	+0 24.5	+1.5	38	44	
28			41	34	
29	+0 26.5	+1.0	37	32	
30			34	32	
31	+0 28.5	+1.0	35	24	
Feb. 1			32	28	
2	+0 30.0	+0.7	32	24	
3			32	24	
4	+0 31.0	+0.5	33	25	
5			34	26	
6	+0 32.0	+0.5	42	26	
7			42	30	
8	+0 32.5	+0.25	37	26	
9			39	27	
10			44	47	

1774	Clock differs from mean time.	Gains or loſes *per diem.*	Mean of Therm. in obſ.	Mean of hygr.	Obſervations.
	′ ″				
Feb. 11			42	40	
12			49	50	
14	+0 33.5	+0.5	46	49	
15			41	41	
16			40	37	
17	+0 35.0	+0.5	41	30	
18	+0 35.5	+0.5	38		

My clock was bought three years ſince at an auction, among the collection of clocks of ſome gentleman, who was curious in that way in London. As ſoon as it arrived I bought it from the purchaſer, a watch-maker: the name is HUGHES. It beats dead ſeconds, goes a month, and is finiſhed both inſide and out with ſo much pains and elegance, that the clock-makers inform me, it muſt have coſt forty pound. It had a common pendulum with a heavy bob. I got a wooden pendulum and a new crutch applied to it exactly according to Mr. LUDLAM's directions, except that the ſpring is longer. For four months after it was put up it went irregularly, upon which I faſtened it to the wall with ſcrew bolts and large waſhers. Since that time, May 1772, it never loſt more than 2″ *per diem*, or gained more than 2″.5, nor did it ever differ more than 1″ in its daily rate on any two ſucceſſive days.

SIR, Corke, Feb. 17, 1778.

I SEND you all the obſervations of any conſequence that have been made here. Some of them are by Mr. NEWENHAM, a young gentleman of conſiderable abilities. He lives on a hill, about 2400 yards E. [anſwering to a difference of meridians of $7\frac{1}{3}$ ſeconds of time] and 600 N. of my obſervatory [anſwering to 18″ difference of latitude] and has a clock with a wooden pendulum; a tranſit teleſcope of 30 inches in length, with an achromatic object-glaſs; and a reflecting teleſcope of eighteen inches focus, made by DOLLOND, magnifying 70 times very diſtinctly. Mr. MAINADUC's obſervatory is 1600 feet due W. of mine [anſwering to a difference of meridian of five ſeconds of time]. The eclipſe of the Sun was obſerved there, for the convenience of the ſide-glaſs, with a tranſit teleſcope of ſmall magnifying power, placed on rack-work; ſo that, though it was a very good obſervation, the beginning may be reckoned three or four ſeconds ſooner. I was unluckily interrupted at the inſtant. The end was not ſeen. The longitude of Corke is, I believe, ſufficiently determined by the occultations. I have calculated ſome of them. If you ſhould take

take that trouble, I ſhall be much obliged to you if you will let me know the reſult.

The account I ſent you of the going of one of my clocks, I am afraid, is not worth laying before the Royal Society, as no concluſion can be deduced from it; but I am certain, that moiſt weather, for any length of time, makes it go ſlower, probably by increaſing the weight of the rod: perhaps covering it with tin-foil would prevent its imbibing moiſture. The other clock, with a mahogany pendulum, does not go well, as the fibres of the wood are not ſtrait, and it warps from the changes of the weather.

I have taken ſome pains to fix the hygrometer to ſome ſtandard, but in vain. One I have had about five years, though adjuſted laſt ſummer, has almoſt loſt the power of abſorbing moiſture; ſo that its contracting is to its lengthening as 1 to 3.

In 1774 I ſent my achromatic teleſcope to DOLLOND and got another from him much better in every reſpect magnifying 150 times, with an achromatic object-glaſs micrometer, and a very firm ſtand and polar axis. It has but one ſet of ſliding tubes at the object end, yet it is very ſteady, and anſwers perfectly well, when once it is fixed to the object.

Being

Being at one time intent on making ſome obſervations with the croſs wires in your manner, I got a ſtand made with an arm, to carry a lanthern that ſhould follow the motion of the teleſcope, and applied a ſolid illuminator to it occaſionally. The account of this I firſt met with in the preface to your admirable obſervations.

I changed the object of my tranſit teleſcope for an achromatic one, got a ſolid illuminator to it, and put in very fine wires, by all which it is much improved.

I am, &c.

Eclipſes

Eclipses of Jupiter's first satellite.

	App. time.	
	h ′ ″	
1772, July 18	12 41 23	Immersion, SHORT's 18 inch R. M. P. 130, by Mr. MAINADUC.
Aug. 3	10 58 27.5	Immersion, achrom. 134.
Sept. 20	8 21 16	Emersion, ditto.
Oct. 6	6 46 12	Emersion, ditto.
1773, Aug. 22	12 52 29	Immersion, ditto.
Nov. 24	10 40 16.5	Emersion, ditto.
1774, Nov. 13	10 20 27	Emersion, achrom. 150.
29	8 34 19	Emersion, ditto.
1775, Jan. 14	8 43 23	Emersion, ditto.
Mar. 1	9 13 16	Emersion, ditto.

By Mr. GEORGE NEWENHAM.

1774, Nov. 29	8 34 42	Emersion, refl. DOLLOND, 70 M. P.
Dec. 8	4 54 56	Emersion, ditto.
22	8 38 45	Emersion, ditto.
1775, Jan. 14	8 43 34	Emersion, ditto.
Sept. 29	16 47 31	Immersion, ditto.
Oct. 1	11 16 41.5	Immersion, ditto.
22	17 1 53.5	Immersion, ditto.
24	11 31 25	Immersion, ditto.

Occultations.

	App. time. h ′ ″	
1773, Apr. 29	11 23 25	1 ♋ Cancri, immerſion.
1774, Apr. 14	6 41 49	♉ Tauri, emerſion.
1775, Sept. 14	11 7 1	γ Tauri, immerſion.
	20 13 12	♉ Tauri, emerſion, uncertain to two ſeconds.
1777, Sept. 21	10 26 39	1 ♑ Tauri, immerſion.
	10 43 28	2 ♑ Tauri, immerſion.

By Mr. NEWENHAM.

1774, Nov. 18	14 35 42	♉ Tauri, immerſion.
	15 52 27	♉ Tauri, emerſion.
1776, Jan. 8	17 59 17.5	♌ Leonis, immerſion.
	18 48 55.5	♌ Leonis, emerſion.

Eclipſe of the Sun.

1778, June 24	2 57 16	Beginning, Mr. MAIRADUC.

Magnetic variation 24° W. in July 1778.

The

The Longitude of Corke ſettled from the foregoing obſervations compared with others made at the Royal Obſervatory at Greenwich. By Nevil Maſkelyne, D. D. *F. R. S. and Aſtronomer Royal.*

THE obſervations made at the Royal Obſervatory at Greenwich neareſt to thoſe made at Corke are as follows, and the error of the Nautical Almanac with reſpect to the time obſerved is ſet down, and alſo the correction of the Nautical Almanac, with reſpect to the time obſerved, and reduced to the effect of a 3½ feet teleſcope, which ſhews the immerſions of the firſt ſatellite ſooner, and the emerſions later, than the ſix feet reflector does by about 13″.

		Apparent time.	Tube of teleſcope.	State of air.	Corr. of Nautical Almanac.	Correction of Naut. Almanac for 3½ teleſcope.
		h ′ ″	Feet.		′ ″	′ ″
1772, July 11	Im.	11 22 25	3½	—	−0 11	−0 21
Aug. 26	Em.	14 4 12	6	Air clear.	−0 19	−0 6
Sept. 27	Em.	10 52 43	3½	Air very clear.	−0 12	−0 12
Oct. 13	Em.	9 17 4	3½	Air clear.	−0 22	−0 22
1773, Aug. 31	Im.	9 51 57	6	Air clear.	−0 3	−0 16
1774, Sept. 10	Im.	15 28 31	6	Air clear & M's belts diſtinct.	+0 57	+0 44
Dec. 19	Em.	11 13 48	6	—	+1 —	+0 9
1775, Feb. 22	Em.	17 49 37	6	Air clear.	+0 29	+0 42
Aug. 7	Im.	14 53 55	6	Air very clear.	+1 28	+1 15
Oct. 22	Im.	17 37 1	6	Air very clear.	+1 33	+1 20

Hence the times of the Nautical Almanac corrected and reduced to the effect of a 3½ feet teleſcope, and compared with the obſervations made at Corke, to find the difference of meridians of Greenwich and Corke, are as follows:

		Obſerved at Corke.	Corr. of Nautical Almanac.	Nautical Almanac corrected.	Diff. of meridians.	Mean.
		h ′ ″	″	h ′ ″	″	
1772, July 18	Im.	12 41 23	−0 11	13 15 37	34 14	per immerſions 34′ 10″.
1773, Aug. 22	Im.	12 52 29	−0 16	13 26 36	34 7	
1772, Sept. 20	Em.	8 21 16	−0 12	8 55 0	33 44	per emerſions 33′ 44″.
1773, Nov. 24	Em.	10 40 26	−0 8	11 14 6	33 50	
1774, Nov. 29	Em.	8 34 19	+0 9	9 8 15	33 56	
1775, Jan. 14	Em.	8 43 25	+0 9	9 17 3	33 40	
Mar. 1	Em.	9 13 16	+0 42	9 46 49	33 29	
				Mean of two results,		33′ 57″.

Hence the difference of meridians of Greenwich and Corke is 33′ 57″ of time, and the longitude of Corke is 8° 29′ 15″ Weſt of Greenwich. The latitude of Corke, as determined by Dr. LONGFIELD, by a mean from two quadrants is 51° 53′ 54″ North.

By Mr. NEWENHAM's obſervations compared in like manner the difference of meridians of Greenwich and his obſervatory is 34′ 11″, which, according to Dr. LONGFIELD's obſervations, allowing 8″ for the difference of meridians,

meridians, owing to the distance of the two observatories, should be 33′ 49″, which latter result is most to be depended upon. The latitude of Mr. NEWENHAM's observatory being 18″ greater than that of Dr. LONGFIELD's, according to the measured distance, is 51° 54′ 12″ North.

XVII. *The Latitude of* Madrafs *in the* East Indies, *deduced from Obſervations made by* William Stephens, *Chief Engineer. Communicated by* John Call, *Eſq.* F. R. S.

Read February 11, 1778.

Time.	What objects.	Latitudes of Madrafs, from Southern Z. diſt.	from Northern Z. diſt.
1776, Oct. 4.	Sun — —	13 3 58	— —
5.	Sun — —	13 4 20	— —
19.	Sun — —	13 4 16	— —
22.	Sun — —	13 3 56	— —
Nov. 1.	β Caſſiopea — —	— —	13 5 42
	α Caſſiopea — —	— —	13 5 58
	γ Caſſiopea — —	— —	13 5 44
	δ Caſſiopea — —	— —	13 5 39
2.	δ Capricorn — —	13 4 29	— —
	Fomalhaut — —	13 4 29	— —
	β Ceti — —	13 3 55	— —
3.	Moon, this rejected in medium,	— —	13 6 58
10.	Sun, very good, —	13 4 9	— —
	1 Lacerta — —	— —	13 5 25
	λ Andromeda (called 12) —	— —	13 5 25
	β Caſſiopea — —	— —	13 5 42
	α Caſſiopea — —	— —	13 15 9
		13 4 11	13 5 37

Mean latitude 13° 4′ 54″ North.

The above obſervations were taken with an aſtronomical braſs quadrant on the top of the houſe uſually inhabited by the chief engineer.

XVIII. *Account of an Infant Muſician.* By Charles Burney, *Doctor of Muſic and F. R. S.*

Read February 18, 1779.

TO DR. WILLIAM HUNTER, F. R. S.

SIR, St. Martin's-ſtreet, Feb. 9, 1779.

AS your curioſity ſeemed much excited by the extraordinary accounts of the Norwich muſical child, and as you expreſſed ſome deſire to know in what particulars his performance was wonderful, and diſpoſition to muſic ſuperior to that of other children of the ſame age: after making all the inquiries my leiſure and opportunities would allow, and repeatedly hearing and ſtudying him, I have drawn up the following account, which, if it does not appear too trivial, I ſhould be glad you would do me the honour of preſenting to the Royal Society, as a mark of my reſpect and veneration for that learned Body, who, as their inquiries extend to all parts of Nature, will perhaps not diſdain to receive a narrative of the uncommon exertions of the human faculties at a more early period of life than they uſually develope.

I have the honour to be, &c.

THAT reaſon begins to dawn, and reflexion to operate, in ſome children much ſooner than in others, muſt be known to every one who has had an opportunity of comparing the faculties of one child with thoſe of another. It has, however, ſeldom been found, that the ſenſes, by which intelligence is communicated to the mind, advance with even pace towards perfection. The eye and the ear, for inſtance, which ſeem to afford reaſon its principal ſupplies, mature at different periods, in proportion to exerciſe and experience; and not only arrive at different degrees of perfection during the ſtages of infancy, but have different limits at every period of human life. An eye or ear that only ſerves the common purpoſes of exiſtence is intitled to no praiſe; and it is only by extraordinary proofs of quickneſs and diſcrimination in the uſe of theſe ſenſes, that an early tendency to the art of painting or muſic is diſcovered.

Many children, indeed, ſeem to recognize different forms, perſons, ſounds, and tones of voice, in very early infancy, who never afterwards endeavour to imitate forms by delineation, or ſounds by vocal inflexions.

As drawing or deſign may be called a refinement of the ſenſe of ſight, and practical muſic of that of hearing; and as a perfection in theſe arts at every period of life,

from

from the difficulty of its attainment, and the delight it affords to the admirers and judges of both, is treated with reſpect, a premature diſpoſition to either uſually excites the ſame kind of wonder as a phenomenon or prodigy.

But as perſons conſummate in theſe arts, and who are acquainted with the uſual difficulties which impede the rapid progreſs of common ſtudents, can only judge of the miraculous parts of a child's knowledge or performance, it will be neceſſary, before I ſpeak of the talents peculiar to the child who is the ſubject of the preſent inquiry, to diſtinguiſh, as far as experience and obſervation ſhall enable me, between a common and ſupernatural diſpoſition, during infancy, towards the art of muſic.

In general a child is not thought capable of profiting from the inſtructions of a muſic-maſter till five or ſix years old, though many have diſcovered an ear capable of being pleaſed with muſical tones, and a voice that could imitate them, much ſooner. The lullaby of a nurſe during the firſt months of a child's exiſtence has been found to ſubdue peeviſhneſs, and, perhaps, divert attention from pain; and in the ſecond year it has often happened, that a child has not only been more diverted with one tune or ſeries of ſounds than another, but has had ſufficient power over the organs of voice to imitate the inflexions by which it is formed; and theſe early proofs of

what is commonly called muſical genius would doubtleſs be more frequently diſcovered if experiments were made, or the mothers or nurſes were muſically curious. However, ſpontaneous efforts at forming a tune, or producing harmony upon an inſtrument ſo early, have never come to my knowledge.

The arts being governed by laws built on ſuch productions and effects as the moſt poliſhed part of mankind have long agreed to call excellent, can make but ſmall approaches towards perfection in a ſtate of nature, however favourable may be the diſpoſition of thoſe who are ſuppoſed to be gifted with an uncommon tendency towards their cultivation. Nature never built a palace, painted a picture, or made a tune: theſe are all works of art. And with reſpect to architecture and muſic, there are no models in nature which can encourage imitation: and though there is a wild kind of muſic among ſavages, where paſſion vents itſelf in lengthened tones different from thoſe of ſpeech, yet theſe rude effuſions can afford no pleaſure to a cultivated ear, nor would be honoured in Europe with any better title than the howlings of animals of an inferior order to mankind.

All therefore that is really admirable in early attempts at muſic is the power of imitation; for elegant melody and good harmony can only be ſuch as far as they correſpond

reſpond with or ſurpaſs their models: and as melody conſiſts in the happy arrangement of ſingle ſounds, and harmony in the artificial combination and ſimultaneous uſe of them, an untaught muſician becomes the inventor of both; and thoſe who are at all acquainted with the infancy of ſuch melody and harmony as conſtitute modern muſic, can alone form an idea of the rude ſtate of both when an individual diſcovers them by the ſlow proceſs of experiment.

Every art when firſt diſcovered ſeems to reſemble a rough and ſhapeleſs maſs of marble juſt hewn out of a quarry, which requires the united and ſucceſſive endeavours of many labourers to form and poliſh. The zeal and activity of a ſingle workman can do but little towards its completion; and in muſic the undirected efforts of an infant muſt be ſtill more circumſcribed: for, without the aid of reaſon and perſeverance he can only depend on memory and a premature delicacy and acuteneſs of ear for his guides; and in theſe particulars the child of whom I am going to ſpeak is truly wonderful.

WILLIAM CROTCH was born at Norwich July 5, 1775. His father, by trade a carpenter, having a paſſion for muſic, of which however he had no knowledge, undertook to build an organ, on which, as ſoon as it would ſpeak, he learned to play two or three common tunes,

ſuch as *God ſave great* GEORGE *our king*; *Let ambition fire thy mind*; and *The Eaſter Hymn*; with which, and ſuch chords as were pleaſing to his ear, he uſed to try the perfection of his inſtrument.

I have been favoured with ſeveral particulars concerning his ſon's firſt attention to muſic from ROBERT PARTRIDGE, eſquire, a gentleman of rank in the Corporation of Norwich, who, at my requeſt, has been ſo obliging as to aſcertain many curious facts, the truth of which, had they reſted merely on the authority of the child's father or mother, might have been ſuſpected; and tranſactions out of the common courſe of nature cannot be too ſcrupulouſly or minutely proved.

My correſpondent, of whoſe intelligence and veracity I have the higheſt opinion, tells me, that I may reſt aſſured of the authenticity of ſuch circumſtances as he relates from the information of the child's father, who is an ingenious mechanic, of good reputation, whom he knows very well, and frequently employs, as theſe circumſtances are confirmed by the teſtimony of many who were witneſſes of the child's early performance; and he adds, that he has himſelf ſeen and heard moſt of the very extraordinary efforts of his genius.

About Chriſtmas 1776, when the child was only a year and a half old, he diſcovered a great inclination for muſic,

muſic, by leaving even his food to attend to it when the organ was playing: and about Midſummer 1777 he would touch the key-note of his particular favourite tunes, in order to perſuade his father to play them. Soon after this, as he was unable to name theſe tunes, he would play the two or three firſt notes of them when he thought the key-note did not ſufficiently explain which he wiſhed to have played.

But, according to his mother, it ſeems to have been in conſequence of his having heard the ſuperior performance of Mrs. LULMAN, a muſical lady, who came to try his father's organ, and who not only played on it, but ſung to her own accompanyment, that he firſt attempted to play a tune himſelf: for, the ſame evening, after her departure, the child cried, and was ſo peeviſh that his mother was wholly unable to appeaſe him. At length, paſſing through the dining-room, he ſcreamed and ſtruggled violently to go to the organ, in which, when he was indulged, he eagerly beat down the keys with his little fiſts, as other children uſually do after finding themſelves able to produce a noiſe, which pleaſes them more than the artificial performance of real melody or harmony by others.

The next day, however, being left, while his mother went out, in the dining-room with his brother, a youth

of

of about fourteen years old, he would not let him reſt till he blew the bellows of the organ, while he ſat on his knee and beat down the keys, at firſt promiſcuouſly; but preſently, with one hand, he played enough of *God ſave great* GEORGE *our King* to awaken the curioſity of his father, who being in a garret, which was his work-ſhop, haſtened down ſtairs to inform himſelf who was playing this tune on the organ. When he found it was the child, he could hardly believe what he heard and ſaw. At this time he was exactly two years and three weeks old, as appears by a copy I have obtained of the regiſter in the pariſh of St. George's Colgate, Norwich, ſigned by the reverend Mr. TAPPS, miniſter. Nor can the age of this child be ſuppoſed to exceed this account by thoſe who have ſeen him, as he has not only all the appearance, but the manners, of an infant, and can no more be prevailed on to play by perſuaſion than a bird to ſing.

It is eaſy to account for *God ſave great* GEORGE *our King* being the firſt tune he attempted to play, as it was not only that which his father often performed, but had been moſt frequently adminiſtered to him as a narcotic by his mother, during the firſt year of his life. It had likewiſe been more magnificently played than he was accuſtomed to hear by Mrs. LULMAN, the afternoon before he became a practical muſician himſelf; and, previous

vious to this event, he uſed to teize his father to play this tune on his organ, and was very clamourous when he did not carry his point.

When his mother returned, the father, with a look which at once implied joy, wonder, and myſtery, deſired her to go up ſtairs with him, as he had ſomething curious to ſhew her. She obeyed, imagining that ſome acquaintance or friend was arrived, or that ſome intereſting event had happened during her abſence; but was as much ſurprized as the father on hearing the child play the firſt part of *God ſave great* GEORGE *our King.* The next day he made himſelf maſter of the treble of the ſecond part; and the day after he attempted the baſe, which he performed nearly correct in every particular, except the note immediately before the cloſe, which, being an octave below the preceding ſound, was out of the reach of his little hand.

In the beginning of November 1777 he played both the treble and baſe of *Let ambition fire thy mind*, an old tune which is, perhaps, now better known by the words to which it is ſung in Love in a Village, *Hope, thou nurſe of young deſire.*

Upon the parents relating this extraordinary circumſtance to ſome of their neighbours, they laughed at it; and, regarding it as the effect of partial fondneſs for

their

their child, adviſed them by no means to mention it, as ſuch a marvellous account would only expoſe them to ridicule. However, a few days after, Mr. CROTCH being ill, and unable to go out to work, Mr. PAUL, a maſter-weaver by whom he was employed, paſſing accidentally by the door, and hearing the organ, fancied he had been deceived, and that CROTCH had ſtayed at home in order to divert himſelf on his favourite inſtrument; fully prepoſſeſſed with this idea, he entered the houſe, and, ſuddenly opening the dining-room door, ſaw the child playing on the organ while his brother was blowing the bellows. Mr. PAUL thought the performance ſo extraordinary, that he immediately brought two or three of the neighbours to hear it, who propagating the news, a croud of near a hundred people came the next day to hear the young performer, and, on the following days, a ſtill greater number flocked to the houſe from all quarters of the city; till, at length, the child's parents were forced to limit his exhibition to certain days and hours, in order to leſſen his fatigue, and exempt themſelves from the inconvenience of conſtant attendance on the curious multitude.

This account agrees in moſt particulars with a letter I received from Norwich, and of which the following is an extract.

"There

"There is now in this city a muſical prodigy, which "engages the converſation and excites the wonder of "every body. A boy, ſon to a carpenter, of only two "years and three quarters old, from hearing his father "play upon an organ which he is making, has diſco- "vered ſuch muſical powers as are ſcarcely credible. He "plays a variety of tunes, and has from memory re- "peated fragments of ſeveral voluntaries which he "heard Mr. GARLAND, the organiſt, play at the cathe- "dral. He has likewiſe accompanied a perſon who "played upon the flute, not only with a treble, but has "formed a baſe of his own, which to common hearers "ſeemed harmonious. If any perſon plays falſe, it "throws him into a paſſion directly; and though his "little fingers can only reach a ſixth, he often attempts "to play chords. He does not ſeem a remarkable "clever child in any other reſpect; but his whole "ſoul is abſorbed in muſic[a]. Numbers croud daily

(a) This opinion ſeems to have been too haſtily formed; for, independent of his muſical talent, he appears to me poſſeſſed of a general intelligence beyond his age: and he has diſcovered a genius and inclination for drawing, nearly as ſtrong as for muſic; for whenever he is not at an inſtrument, he uſually employs himſelf in ſketching, with his left-hand, houſes, churches, ſhips, or animals, in his rude and wild manner, with chalk on the floor, or upon whatever other plain ſurface he is allowed to ſcrawl. Painters may, perhaps, form ſome judgment of his muſic by his drawings.

" to hear him, and the muſical people are all amaze-
" ment[b]."

The child being but two years and eight months old when this letter was written, his performance muſt have appeared conſiderably more wonderful than at preſent: for as he ſeems to have received ſcarce any inſtructions, and to have purſued no regular courſe of ſtudy or practice ſince that time, it can hardly be imagined that he is much improved. However, experience muſt have informed him what ſeries or combination of ſounds was moſt offenſive to his ear; but ſuch is his impetuoſity that he never dwells long on any note or chord, and indeed his performance muſt originally have been as much under the guidance of the eye as the ear, for when his hand unfortunately falls upon wrong notes, the ear cannot judge till it is too late to correct the miſtake. However, habit, and perhaps the delicacy and acuteneſs of another ſenſe, that of feeling, now direct him to the keys which he preſſes down, as he hardly ever looks at them.

(b) His father, who has lately been in London, and with whom I have converſed ſince this account was drawn up, all the particulars of which he has confirmed, told me, that when he firſt carried the child to the cathedral he uſed to cry the inſtant he heard the loud organ, which, being ſo much more powerful than that to which he had been accuſtomed at home, he was ſome time before he could bear without diſcovering pain, occaſioned, perhaps, by the extreme delicacy of his ear, and irritability of his nerves.

The firſt voluntary he heard with attention was performed at his father's houſe by Mr. MULLY, a muſic-maſter; and as ſoon as he was gone, the child ſeeming to play on the organ in a wild and different manner from what his mother was accuſtomed to hear, ſhe aſked him what he was doing? And he replied, "I am playing "the gentleman's fine thing." But ſhe was unable to judge of the reſemblance: however, when Mr. MULLY returned a few days after, and was aſked, whether the child had remembered any of the paſſages in his voluntary, he anſwered in the affirmative. This happened about the middle of November 1777, when he was only two years and four months old, and for a conſiderable time after he would play nothing elſe but theſe paſſages.

A muſical gentleman of Norwich informed Mr. PARTRIDGE, that, at this time, ſuch was the rapid progreſs he had made in judging of the agreement of ſounds, that he played the Eaſter-Hymn with full harmony; and in the laſt two or three bars of *Hallelujah*, where the ſame ſound is ſuſtained, he played chords with both hands, by which the parts were multiplied to ſix, which he had great difficulty in reaching on account of the ſhortneſs of his fingers. The ſame gentleman obſerved, that in making a baſe to tunes which he had recently caught by his ear, whenever the harmony diſpleaſed him, he would con-

tinue the treble note till he had formed a better accompanyment.

From this period his memory was very accurate in retaining any tune that pleaſed him: and being preſent at a concert where a band of gentlemen-performers played the overture in Rodelinda, he was ſo delighted with the minuet, that the next morning he hummed part of it in bed; and by noon, without any further aſſiſtance, played the whole on the organ.

His chief delight at preſent is in playing voluntaries, which certainly would not be called muſic if performed by one of riper years, being deficient in harmony and meaſure; but they manifeſt ſuch a diſcernment and ſelection of notes as is truly wonderful, and which, if ſpontaneous, would ſurprize at any age. But though he executes fragments of common tunes in very good time, yet no adherence to any particular meaſure is diſcoverable in his voluntaries; nor have I ever obſerved in any of them that he tried to play in triple time. If he diſcovers a partiality for any particular meaſure, it is for dactyls of one long and two ſhort notes, which conſtitute that ſpecies of common time in which many ſtreet-tunes are compoſed, particularly the firſt part of the Belleiſle March, which, perhaps, may firſt have ſuggeſted this meaſure to him, and impreſſed it in his memory. And

his

his ear, though exquiſitely formed for diſcriminating ſounds, is as yet only captivated by vulgar and common melody, and is ſatisfied with very imperfect harmony. I examined his countenance when he firſt heard the voice of Signor PACCHIEROTTI, the principal ſinger of the opera, but did not find that he ſeemed ſenſible of the ſuperior taſte and refinement of that exquiſite performer; however, he called out very ſoon after the air was begun, "He is ſinging in F."

And this is one of the aſtoniſhing properties of his ear, that he can diſtinguiſh at a great diſtance from any inſtrument, and out of ſight of the keys, any note that is ſtruck, whether A, B, C, &c. In this I have repeatedly tried him, and never found him miſtaken even in the half notes; a circumſtance the more extraordinary, as many practitioners and good performers are unable to diſtinguiſh by the ear at the opera or elſewhere in what key any air or piece of muſic is executed.

But this child was able to find any note that was ſtruck in his hearing, when out of ſight of the keys, at two years and a half old, even before he knew the letters of the alphabet: a circumſtance ſo extraordinary, that I was very curious to know when, and in what manner, this faculty firſt diſcovered itſelf; and his father ſays, that in the middle of January 1778, while he was playing the organ, a particular note hung, or, to ſpeak the language

language of organ-builders, ciphered, by which the tone was continued without the preſſure of the finger: and though neither himſelf nor his elder ſon could find out what note it was, the child, who was then amuſing himſelf with drawing on the floor, left that employment, and going to the organ immediately laid his hand on the note that ciphered[c]. Mr. CROTCH thinking this the effect of chance, the next day purpoſely cauſed ſeveral notes to cipher, one after the other, all which he inſtantly diſcovered: and at laſt he weakened the ſprings of two keys at once, which, by preventing the valves of the wind-cheſt from cloſing, occaſioned a double cipher, both of which he directly found out. Any child, indeed, that is not an idiot, who knows black from white, long from ſhort, and can pronounce the letters of the alphabet by which muſical notes are called, may be taught the names of the keys of the harpſichord in five minutes[d]; but, in general, five years would not be ſufficient, at any age, to impreſs the mind of a muſical ſtudent with an infallible reminiſcence of the tones produced by theſe keys, when not allowed to look at them.

(c) This circumſtance proves that he exerciſed his eye in drawing, after his manner, before he was two years and a half old.

(d) By remarking that the ſhort keys, which ſerve for flats and ſharps, are divided into parcels of threes and twos, and that the long key between every two ſhort keys is always called D, it is extremely eaſy from that note to diſcover the ſituation and names of the reſt, according to the order of the firſt ſeven letters of the alphabet.

Another

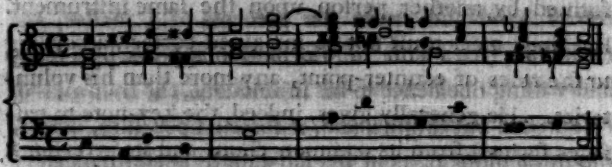
Another wonderful part of his pre-maturity was the being able at two years and four months old to tranſpoſe into the moſt extraneous and difficult keys whatever he played; and now, in his extemporaneous flights, he modulates into all keys with equal facility.

The laſt qualification which I ſhall point out as extraordinary in this infant muſician, is the being able to play an extemporary baſe to eaſy melodies when performed by another perſon upon the ſame inſtrument. But theſe baſes muſt not be imagined correct, according to the rules of counter-point, any more than his voluntaries. He generally gives, indeed, the key-note to paſſages formed from its common chord and its inverſions, and is quick at diſcovering when the fifth of the key will ſerve as a baſe. At other times he makes the third of the key ſerve as an accompaniment to melodies formed from the harmony of the chord to the key-note; and if ſimple paſſages are played ſlow, in a regular progreſſion aſcending or deſcending, he ſoon finds out that thirds or tenths, below the treble, will ſerve his purpoſe in furniſhing an agreeable accompaniment.

However, in this kind of extemporary baſe, if the ſame paſſages are not frequently repeated, the changes of modulation muſt be few and ſlow, or correctneſs cannot be expected even from a profeſſor. The child is always as ready at finding a treble to a baſe as a baſe to a treble,

if

if played in ſlow notes, even in chromatic paſſages; that is, if, after the chord of C natural is ſtruck, C be made ſharp, he ſoon finds out that A makes a good baſe to it; and on the contrary, if, after the chord of D with a ſharp third, F is made natural, and A is changed into B, he inſtantly gives G for the baſe. Indeed he continued to accompany me with great readineſs in the following chromatic modulation, aſcending and deſcending:



I made more experiments of this kind, but to relate them would render my account too technical to all but compoſers, or ſuch as have long ſtudied harmony.

When he declares himſelf tired of playing on an inſtrument, and his muſical faculties ſeem wholly blunted, he can be provoked to attention, even though engaged in any new amuſement, by a wrong note being ſtruck in the melody of any well-known tune; and if he ſtands by the inſtrument when ſuch a note is deſignedly ſtruck, he will inſtantly put down the right, in whatever key the air is playing.

At preſent, all his own melodies are imitations of common and eaſy paſſages, and he ſeems inſenſible to others; however,

however, the only method by which such an infant can as yet be taught any thing better seems by example. If he were to hear only good melody and harmony, he would doubtless try to produce something similar; but, at present, he plays nothing correctly, and his voluntaries are little less wild than the native notes of a lark or a black-bird. Nor does he, as yet, seem a subject for instruction: for till his reason is sufficiently matured to comprehend and retain the precepts of a master, and something like a wish for information appears, by a ready and willing obedience to his injunctions, the trammels of rule would but disgust, and, if forced upon him, destroy the miraculous parts of his self-taught performance.

Mr. BAILLET published in the last century a book, *Sur les Enfans celebres par leurs etudes*; and yet, notwithstanding the title of his work, he speaks not of infants but adolescents, for the youngest wonder he celebrates in literature is at least seven years old; an age at which several students in music under my own eye have been able to perform difficult compositions on the harpsichord, with great neatness and precision. However, this has never been accomplished without instructions and laborious practice, not always voluntary.

Musical prodigies of this kind are not infrequent: there have been several in my own memory on the harpsichord. About thirty years ago I heard FALSCHAU, a

German boy of nine or ten years old, then in London, perform with great accuracy many of the moſt difficult compoſitions that have ever been written for keyed inſtruments, particularly ſome leſſons and double fugues by SEBASTIAN BACH, the father of the preſent eminent profeſſors of that name, which, at that time, there were very few maſters in Europe able to execute, as they contained difficulties of a particular kind; ſuch as rapid diviſions for each hand in a ſeries of thirds, and in ſixths, aſcending and deſcending, beſides thoſe of full harmony and contrivance in nearly as many parts as fingers, ſuch as abound in the leſſons and organ fugues of HANDEL.

Miſs FREDERICA, now Mrs. WYNNE, a little after this time, was remarkable for executing, at ſix years old, a great number of leſſons by SCARLATTI, PARADIES, and others, with the utmoſt preciſion.

But the two ſons of the reverend Mr. WESTLEY ſeem to have diſcovered, during early infancy, very uncommon faculties for the practice of muſic. CHARLES, the eldeſt, at two years and three quarters old, ſurprized his father by playing a tune on the harpſichord readily, and in juſt time: ſoon after he played ſeveral, whatever his mother ſung, or whatever he heard in the ſtreet.

SAMUEL, the youngeſt, though he was three years old before he aimed at a tune, yet by conſtantly hearing his brother practiſe, and being accuſtomed to good muſic

and maſterly execution, before he was ſix years old arrived at ſuch knowledge in muſic, that his extemporary performance on keyed inſtruments, like MOZART's, was ſo maſterly in point of invention, modulation, and accuracy of execution, as to ſurpaſs, in many particulars, the attainments of moſt profeſſors at any period of their lives.

Indeed MOZART, when little more than four years old, is ſaid to have been "not only capable of executing leſ-"ſons on his favourite inſtrument, the harpſichord, but "to have compoſed ſome in an eaſy ſtyle and taſte, which "were much approved (c)." and SAMUEL WESTLEY before he could write was a compoſer, and mentally ſet the airs of ſeveral oratorios, which he retained in memory till he was eight years old, and then wrote them down.

Here the difference of education appears: little CROTCH, left to nature, has not only been without inſtructions but good models of imitation; while MOZART and SAMUEL WESTLEY, on the contrary, may be ſaid to have been nurſed in good muſic: for as the latter had his brother's excellent performance to ſtimulate attention, and feed his ear with harmony; the German infant, living in the houſe of his father, an eminent profeſſor,

(c) See Phil. Tranſ. vol. LX. for the year 1770, an account of a very remarkable young muſician, by the honourable DAINES BARRINGTON, F. R. S. who ſoon intends to favour the public with an account of the two WESTLEYS.

and an elder ſiſter, a neat player on the harpſichord, and conſtantly practiſing compoſitions of the firſt claſs for that inſtrument, had every advantage of ſituation and culture joined to the profuſion of natural endowments.

Of MOZART's infant attempts at muſic I was unable to diſcover the traces from the converſation of his father; who, though an intelligent man, whoſe education and knowledge of the world did not ſeem confined to muſic, confeſſed himſelf unable to deſcribe the progreſſive improvements of his ſon during the firſt ſtages of infancy. However, at eight years of age I was frequently convinced of his great knowledge in compoſition by his writings; and that his invention, taſte, modulation, and execution in extemporary playing, were ſuch as few profeſſors are poſſeſſed of at forty years of age.

Into what the preſent prodigy may mature is not eaſy to predict; we more frequently hear of trees in bloſſom during the winter months than of fruits in conſequence of ſuch unſeaſonable appearances. However, to keep pace with the expectations to which ſuch premature talents give birth is hardly allowed to humanity. It is the wiſh of ſome, that the uncommon faculties with which this child is endowed might be ſuffered to expand by their own efforts, neither reſtrained by rules, nor guided by examples; that, at length, the world might be furniſhed with a ſpecies of natural muſic, ſuperior to all the ſurprizing productions

productions of art to which pedantry, affectation, or a powerful hand, have given birth. But, alas! ſuch a wiſh muſt have been formed without reflexion; for muſic having its claſſics as well as poetry and other arts, what could he compoſe or play upon different principles that would not offend the ears of thoſe who have regarded thoſe claſſics as legiſlators, and whoſe ſouls have been wrapped in elyſium by their ſtrains? He might as well, if ſecluded from all intercourſe with men, be expected to invent a better language than the preſent Engliſh, the work of millions, during many centuries, as a new muſic more grateful to the ears of a civilized people than that with which all Europe is now delighted.

An individual may doubtleſs advance nearer perfection in every art by the aſſiſtance of thouſands, than by the mere efforts of his own labour and genius.

Another wiſh has been formed, that the effects of different genera and diviſions of the muſical ſcale might be tried upon this little muſician; but the ſucceſs of ſuch an experiment is not difficult to divine. An uncultivated ear would as naturally like the moſt plain and common muſic, as a young mind would beſt comprehend the moſt ſimple and evident propoſitions: and, as yet, the attention of CROTCH cannot be excited by any muſical refinements or elaborate contrivance.

It

It has likewiſe been imagined by ſome, that every child might be taught muſic in the cradle, if the experiment were made; but to theſe it may with truth be ſaid, that ſuch an experiment is *daily* made on every child, by every mother and nurſe, that is able to form a tune, on every part of the globe. In Italy the *ninne nonne*, or lullabies, are fragments of elegant melodies, become common and popular by frequent hearing; and theſe, though they help to form the national taſte, are not found to ſtimulate the attention of Italian children to melody, or to accelerate the diſplay of muſical talents at a more early period than elſewhere.

Premature powers in muſic have as often ſurprized by ſuddenly becoming ſtationary as by advancing rapidly to the ſummit of excellence. Sometimes, perhaps, nature is exhauſted or enfeebled by theſe early efforts; but when that is not the caſe, the energy and vigour of her operations are ſeldom properly ſeconded, being either impeded and checked by early ſelf-complacence, or an injudicious courſe of ſtudy; and ſometimes, perhaps, genius is kept from expanſion by ill-choſen models; excluſive admiration, want of counſel, or acceſs to the moſt excellent compoſitions and performers in the claſs for which nature has fitted thoſe on whom it is beſtowed.

XIX. *Account of a new Method of cultivating the Sugar Cane. By Mr.* Cazaud; *communicated by* Joseph Banks, *Esq. P. R. S.*

Read February 25, 1779.

CONTENTS.

Page.
OBSERVATIONS on the climate, - - 216
Table of the rain fallen in the Eastern part of the island of Grenada, from the first of June 1772 to the first of June 1773, - - 217
Natural history of the cane, - - 218
History

Systeme de la petite Culture des Cannes à Sucre. Par M. Cazaud.

TABLE DES ARTICLES.

Page.
OBSERVATIONS sur le climat, - - - 216
Tableau de la pluie tombée à la Grenade dans la partie de l'est depuis le 1 Juin 1772 jusqu'au premier Juin 1773, - - 217
Histoire naturelle de la canne, - - - - 218
Histoire

History of the roots of the cane, and of its productions under ground, - - 219
History of the joints of the cane above ground, 241
History of the cane in different ſoils, with that of the different degrees and different kinds of growth it is ſubject to in them, - 250
History of a revolution in the inſide of the cane, and of the arrow which comes out in conſequence of that revolution, and conſtitutes the laſt ſtage of the plant's exiſtence - - - 264
History of the cane according to the two different methods of cultivation, and in different years, favourable, dry, and rainy, - - 270
View of the cane in its different ſtages, - 278

View

Hiſtoire des racines de la canne et de ſes productions en terre, - 219
Hiſtoire des nœuds de la canne hors de terre, - - - 241
Hiſtoire de la canne dans les differentes eſpeces de terres, des divers degrés et de l'eſpece d'accroiſſement qu'elle y acquiert, - - 250
Hiſtoire d'une revolution ſinguliere dans l'interieur de la plante, de la fleche qui la ſuit et qui forme le dernier developpement de la canne, 264
Hiſtoire de la canne dans les deux ſyſtemes et dans les differentes eſpéces d'années, favorables, ſeches et pluvieuſes, - - 270
Vue de la canne dans ſes differens periodes, - - 278

Vue

THOUGH the work which I have the honour to lay before the Royal Society was undertaken entirely with a view to private advantage, it appeared to me not entirely deſtitute of public utility, were that utility no other than what may ariſe from there exiſting a regular hiſtory of a plant which is worth nine millions ſterling to Europe.

The uſual method of cultivating the ſugar cane appears more like the conſequence of ſome general obſervations than the reſult of ſuch as ought to have been purpoſely made.

The methods in uſe, before mine, are reducible to two.

The

L'OUVRAGE que j'ay l'honneur de preſenter et de ſoumettre au jugement de la Societé Royale de Londres, entrepris uniquement pour des vues particulieres, m'a paru ſuſceptible d'une utilité générale, quand il ne devroit produire qu'une diſcuſſion ſur une plante qui fournit à l'Europe une reproduction annuelle de neuf millions ſterling.

La culture ordinaire de la canne me paroit plutôt être le fruit de quelques obſervations générales que le reſultat de celles qu'on auroit du faire.

On peut reduire à deux methodes, les ſyſtemes établis avant celuy que je propoſe.

The one conſiſts in making ſugar in almoſt all ſeaſons indifferently, conſequently in planting rather (if one may ſo ſay) when the planter is beſt prepared for his work, than at the time which is beſt ſuited to the eſſential end, which undoubtedly ſhould be, *to get from the earth, all that can be expected from its fruitfulneſs after due allowance has been made for the different circumſtances of the growth of the cane, and the revolutions it undergoes in the different ſeaſons.*

This firſt method aroſe, from the want of proper obſervations, and the difficulty of procuring the number of negroes requiſite to work in another manner; ſo that the deſire of cultivating a greater quantity of land always having kept pace with the augmentation

---

L'une conſiſte à faire du ſucre preſque indiſtinctement en tout tems, et conſéquemment à planter, s'il eſt permis de le dire, plutôt dans le tems où l'on eſt le mieux arrangé pour cette operation, que dans celuy qui conviendroit le plus au but eſſentiel, qui doit être, *de tirer de la terre tout ce qu'on peut eſpérer de ſa fertilité, combinés avec les différentes circonſtances de l'accroiſſement de la canne, et des revolutions qu'elle éprouve dans les différentes ſaiſons.*

Cette methode a été une ſuite neceſſaire de la difficulté qu'on avoit dans le principe de ſe procurer la quantité de negres qu'il auroit fallu pour travailler autrement, jointe au manque d'obſervations qui puſſent encore diriger. Le deſir de cultiver une plus grande quantité de terre augmentant avec le nombre des negres,

tation of the negroes, the latter muſt of courſe have been always inadequate to the work; whence the only change ſuch a method of culture could ever admit of conſiſted in making a little more ſugar in a good ſeaſon, and a little leſs in a bad one.

The ſecond method, which I call the ſyſtem of cultivation in the great way, and is that which has been either originally followed or adopted wherever the number of negroes has been anſwerable to the aſſurance the ſlave-merchant had of receiving the price he had agreed to take for them, conſiſts, firſt, in planting a fourth or fifth of one's land in October, November, and December, when, all the other buſineſs of the plantation being finiſhed, there is time to give to this important one all the attention it deſerves.

2dly,

---

negres, dont la quantité ſe trouvoit toujours ainſi diſproportionée aux travaux, le ſeul changement que l'avidité d'etendre ſes plantations ait pu admettre dans le premier plan, a donc été de faire un peu plus de ſucre dans la bonne ſaiſon et un peu moins dans la mauvaiſe.

L'autre methode que j'appelle le ſyſteme de la grande culture a été ſuivie où adoptée dans tous les païs où la facilité de ſe procurer des negres a été proportionnée à l'avantage qu'on avoit ſoin d'aſſurer au marchand, d'en recevoir le payement aux termes ſtipulés. Cette methode conſiſte, 1°, à planter le quart où le cinquieme de ſa terre en Octobre, Novembre, et Decembre, parce qu'alors tous les autres travaux etant finis, on eſt tout entier à cette opération importante.

2dly, In digging very deep trenches, becauſe the deeper the trench the greater the nouriſhment of the root.

3dly, In planting at great diſtances, by which the air circulates more freely between the plants, and by that means enſures them a quicker and more compleat maturity.

Finally, in cutting the canes in the four fineſt months of the year, to wit, in February, March, April, and May, becauſe the ſugar is then the fineſt, is cut with the leaſt trouble, and (at leaſt as is pretended) is ſupplied in greater quantities by the canes.

Where this method is followed, about three fourths of the plantation is cut, the remainder is made up partly of young canes, which can only be cut the following year, and partly of ſuch as muſt neceſſarily be ſacrificed and reſerved for the purpoſe of getting

---

2°, à faire des foſſes très profondes, parce que les racines trouvent plus de nourriture dans une plus grande profondeur.

3°, à planter à de grandes diſtances, parce que l'air circule mieux entre les plantes, et leur procure une maturité plus prompte et plus parfaite.

4°, enfin, à faire la recolte pendant les 4 mois de la plus belle ſaiſon, Fevrier, Mars, Avril, May, parce qu' alors le ſucre ſe fait plus aiſément, plus beau, et que les cannes, dit-on, en donnent une plus grande quantité.

On coupe dans ce ſyſteme environ les trois quarts de la terre deſtinée aux cannes; le reſte eſt partie en jennes plantes qu'on ne peut couper que l'année d'après, et partie dans quelque portion de terre ſacrifiée neceſſairement pour ſe procurer

getting the plants which are wanted after the crop is over.

My own method, which I now proceed to explain, is this: I employ the whole of the ſix firſt months of the year in the buſineſs of the crop, and in May and June plant the canes which have been cut in January. This of courſe induces a neceſſity of cutting the rattoons at the end of the eleventh inſtead of the end of the twelfth month, and the planted canes, which ſhould ſtand fifteen months, at the end of the year: in return, the whole plantation is cut every year.

It is objected, that beſides the firſt loſs from cutting the rattoons one, and the planted canes three months before their time, there is a ſecond which ariſes from what is cut not being ſufficiently ripe. Theſe objections I mean to anſwer by the hiſtory of the cane, that of the ſeaſons, that

---

procurer le plan dont on a beſoin dans une ſaiſon où la recolte eſt déja faite.

Je propoſe d'employer en entier les ſix premiers mois de l'année à faire la recolte, et de planter en May et Juin, les cannes coupées en Janvier, ce qui entraine la neceſſité de couper toujours, les rejettons à onze mois au lieu de les couper à douze, et les cannes plantées à un au lieu de les couper à 15 mois: mais on coupe chaque année toute la terre deſtinée aux cannes.

On objecte à ce ſyſteme, outre la perte qui reſulte de l'anticipation d'un mois de coupe pour les rejettons, et de trois mois pour les cannes plantées, le defaut de maturité qui ſuit de cette anticipation; je réponds à ces objections par l'hiſtoire de

that of the effect of thoſe ſeaſons, and from experience.

After this, as it is an advantageous conſequence (though not a fundamental principle) of my method, that I only plant a ſixth part of my land every year, and it is objected to this, that there are ſome ſoils which will not give ſo much as a *ſecond* crop, I endeavour to inveſtigate what cauſes can deprive a plant propagating by the gem of its power of giving ſhoots *ad infinitum*, and I find none but ſuch ariſe from a bad method of cultivation.

Having written in the beginning only with a view of inſtructing my overſeer, and by no means with the preſumption of adding to the treaſure of natural hiſtory by the account of a plant which deſerves the pen of a BUFFON, my obſervations (though I flatter myſelf extended to every

---

de la canne, des ſaiſons, de leurs effets, et de l'expérience.

Je ne plante auſſi annuellement que le ſixieme de ma terre, mais ce n'eſt pas l'article fondamental du ſyſteme, il me paroit ſeulement en être une ſuite avantageuſe: cependant comme on objecte contre cet article, l'impoſſibilité prétendue, même d'une ſeconde coupe dans certaines terres, je cherche les raiſons qui peuvent anéantir, dans une plante vivace par ſa racine, la faculté de rejetonner juſqu'a la conſommation des ſiecles; et je ne puis les trouver que dans un mauvais ſyſtême de culture.

Quoique je n'aye ecrit dans le principe que pour inſtruire mon œconome, et point du tout avec la préſomption d'enrichir le depot d'hiſtoire naturelle, de celle d'une plante digne de la plume d'un BUFFON, je ne crois pas cependant qu'il y ait un ſeul point intereſſant de cette hiſtoire qui m'ait echappé, mais tous

every material point) were ſcattered, confuſed and drawn up in the natural order they offered themſelves to me, when the neceſſity of diſcuſſing or defending any part of my method obliged me to ſtudy the nature of the plant, to try to find out the reaſon of ſome phenomena which the experience of many years had taught me the exiſtence of; but I have been obliged to follow a different method now that theſe obſervations are to be ſubmitted to the natural judges of every thing that can have influence upon the progreſs of uſeful knowledge. In order to form a proper judgment of the merit of the mode of culture I propoſe, it is neceſſary to be acquainted with the plant and the climate in which it grows.

Obſer-

---

etoient epars, ſans ordre, comme ils s'etoient preſentés, à meſure qu'il falloit diſcuter et etablir quelque partie de mon ſyſteme, et que j'étois obligé de chercher dans la nature de la plante, la raiſon de quelque phenomene que pluſieurs années d'expérience m'avoient fait obſerver. Mon deſſein en les rapprochant, etant de les preſenter aux juges naturels de tout ce qui peut influer ſur le progrès des connoiſſances utiles, j'ay du ſuivre une autre methode: pour apprécier la culture que je propoſe il faut connoître la plante, et le climat où on la cultive.

Obſer-

Observations on the climate.

In the Windward Iſlands, the weather is commonly dry from the 15th of February to the 15th of May. The rains are moderate till Auguſt; they are very copious the two or three following months, and afterwards decreaſe till February; conſequently there is a ſucceſſion of nine months rain, and of three months dry weather. The annexed table ſhews the quantity of rain fallen at Grenada in the Eaſt quarter from the firſt of June 1772 to the firſt of June 1773, and this is the rain of a common year.

Table

Obſervations ſur le climat.

Dans les Iſles Antilles, du 15 Fevrier au 15 May, il fait ordinairement ſec, les pluyes ſont moderées juſqu'en Aouſt, elles ſont tres fortes pendant les deux où trois mois ſuivants, elles diminuent enſuite juſqu'en Fevrier: voila donc une ſucceſſion de neuf mois de pluye ſuivie de trois mois de ſec; voici le tableau de la pluye tombée à la Grenade dans la partie de l'eſt depuis le 1 Juin 1772 juſqu'au 1 Juin 1773; c'eſt le tableau d'une année commune.

Tableau

Table of rain fallen in the East quarter of Grenada *from the 1st of* June 1772 *to the 1st of June* 1773.

	In.	Tenths of an inch Eng. measure.
June -	9	3
July -	13	9
August -	11	9
September -	19	0
October -	12	7
November -	9	1
December -	18	8
January -	9	5
February -	6	4
March -	2	6
April -	0	8
May -	2	9
Total of inches of rain,	116	0

The

Tableau de la pluye tombée à la Grenade *dans la partie de l'est depuis le* 1 Juin 1772 *jusqu'au* 1 Juin 1773.

	Pou.	10es de pouce Anglois.
Juin -	9	3
Juillet -	13	9
Aouft -	11	9
Septembre -	19	0
Octobre -	12	7
Novembre -	9	1
Decembre -	18	8
Janvier -	9	5
Fevrier -	6	4
Mars -	2	6
Avril -	0	8
May -	2	9
Total des pouces d'eau	116	0

The natural history of the cane.

There are but few of the minute particulars I am going to mention, but what are some how or other connected with my method.

The upper part of the cane, commonly called the head, is the best plant that can be used to propagate it, see fig. 7. see likewise fig. 1.; it is the part from *l* to *n*, which in this figure is without its leaves. It is a known fact, that the body of the cane does not come up well, unless there are continued rains from the time of its being put into the ground, till all the shoots are out and pretty strong.

History

Histoire naturelle de la canne.

Il est peu des details minutieux dans lesquels je vais entrer qui n'ait un rapport quelquconque avec mon système.

La partie superieure de la canne appellée communement la tête, est le meilleur plan dont on puisse se servir pour la multiplier, v. fig. 7. v. auſſi fig. 1. c'est la partie depuis *l* jusqu'a *n*, elle est dans cette figure depouillée de ses feuilles: il est reconnu que le corps de la canne ne reussit point à moins d'une pluye continuelle depuis le moment qu'il est en terre, jusqu'au moment où tous les jets sont sortis et assez vigoureux.

Histoire

Hiſtory of the roots of the ſugar cane, and of its productions under ground.

If the plant be put into the ground as ſoon as it is cut, and the weather happens to be very hot and dry, a fortnight often paſſes before the eye can diſcover any alteration in the two or three moſt promiſing joints; the firſt being too hard (ſee *a* fig. 2.) become immediately dry; the others (ſee from *y* to *z* in the ſame figure) are only graſs, and produce nothing, unleſs when the laſt happens to ſhoot at its extremity.

When the dry weather continues, but ſo as not materially to affect the ſoil in contact with the inferior part of the plant, one diſcovers at the end of three weeks, about that part of the joint which lies undermoſt in the trench, ſome

---

Hiſtoire des racines de la canne et de ſes productions en terre.

1°, Si le plan eſt mis en terre auſſi tôt qu'il eſt coupé, et qu'il ſurvienne de grandes chaleurs ſans pluye, il eſt ſouvent quinze jours ſans que l'œil decouvre la moindre alteration dans les deux ou trois nœuds de la plus grande eſpérance; les premiers, trop durs, v. *a*, fig. 2. ſont d'abord deſſechés; les autres, herbacés, v. *y* juſqu'a *z*, ne produiſent rien à moins que le dernier ne ſe developpe par ſon extremité.

Si le ſec continue et qu'il ne ſe faſſe pas ſentir vivement juſqu'à la terre qui touche la partie inferieure du plan, ou decouvre après trois ſemaines à cette partie

ſome white fibres of about half a line in length and thickneſs: notwithſtanding, however, this beginning of vegetation, the plant ſtill dies, unleſs it rains, before the ſoil in contact with theſe ſmall roots be entirely dry; at leaſt I have always found the earth dry under theſe ſmall roots, when, in conſequence of a long drought, the plant from which they had come was entirely dried up. But I have ſeen plants, put into the ground as ſoon as cut, put forth one, and ſometimes two ſprigs at the end of ſix weeks, though they had been deprived of rain for above a month. When the plant is ſomewhat withered, that is, when it has not been planted till ſome days after having been cut, it thrives ſooner when aſſiſted by rain, and dies ſooner when deprived of it: the reaſon I take to be this, it could not wither without loſing ſome part of that moiſture which it contains, and which it wanted

---

du nœud qui touche le fond de la foſſe, quelques fils blancs de la longueur et de la groſſeur d'une demi ligne: après ce commencement de végetation, le plan meurt s'il ne pleut pas avant que la terre qui touche ces petites racines ſoit entiérement deſſechée, ou du moins j'ay toujours trouvé la terre ſeche ſous ces petites racines lorſqu'après un long ſec, j'ay trouvé le plan qui les avoit données entiérement deſſeché; mais j'ay vu du plan mis en terre auſſi-tôt que coupé privé de pluye pendant plus d'un mois donner un et quelquefois deux jets après ſix ſemaines: ſi le plan eſt un peu fanné, c'eſt à dire coupé quelques jours avant d'être mis en terre, il leve plus vite s'il eſt ſecondé de la pluye, et meurt plutôt s'il en eſt privé, parce qu'il n'a pu ſe fanner ſans perdre une partie de l'eau qu'il contenoit, dont

wanted to preſerve it from the dryneſs of the ſurrounding earth, which earth itſelf alſo probably ſucks up part of its humidity: *I am, therefore, apt to think, though contrary to the opinion of a great many people, that it is beſt to put the plant into the ground as ſoon as it is cut.*

2dly, We all along ſuppoſe the weather to be tolerably favourable; then, when the ſmall roots, which ſprout about the joint when the ſurrounding earth has its proper degree of moiſture, are of the length of a line and a half or two lines, the bud adherent to it ſwells; a few days after it lengthens horizontally in the direction of the plant, ſee *b*, fig. 2.; it next deſcribes a ſpiral, *c*; and at length comes out of the earth like the point of an arrow, *d*. Theſe are what we call the firſt productions; they are the immediate productions of the plant. The ſhaft

---

il auroit eu beſoin pour ſe ſoutenir plus longtems contre la ſechereſſe de la terre qui l'environne, et qui probablement pompe même une partie de ſon humidité: *je crois donc contre l'opinion de beaucoup de gens qu'il vaut mieux mettre le plan en terre auſſi-tôt qu'il eſt coupé.*

2°. Nous ſuppoſerons un tems aſſez favorable; lorſque ces petites racines qui ſe forment à l'entour du nœud ſi la terre eſt par tout humide, ſont longues d'une ligne et demie ou deux, le bouton qui luy eſt attaché paroit gonflé, quelques jours après il s'allonge horizontalement, v. *b*, fig. 2. ſuivant la direction dans laquelle le plan eſt couché, enſuite il decrit une ſpirale, v. *c*, même figure, et ſort de terre comme une pointe de fleche *d*. C'eſt ce que j'appelle les premières productions,

ſhaft of the arrow then breaks, the two firſt leaves expand, ſee *e*, *e*, fig. 3. and riſe from twenty-four to thirty inches high. Theſe are, properly ſpeaking, the leaves of the plant, I ſhall call them the *external* leaves, though they are in fact incloſed within a quadruple ſheath of ſeminal leaves, ſee *f*, *f*, *f*, *f*; but theſe laſt riſe but a very little way out of the ground. I believe, that the joint, to which the laſt leaf of this external caſe is faſtened, ought to be conſidered as the beginning of the ſtem of the plant which divides its lower part (that which produces nothing above ground) from its upper part, which produces things of various kinds; at leaſt, I have never ſeen any thing produced by this lower part, except theſe four ſmall leaves, and ſome roots.

3dly,

---

tions, qui ſont les productions directes du plan, Deux ou trois jours après, le faiſceau qui compoſe cette fleche ſe developpe, les deux premieres feuilles ſe deployent, v. *ee*, fig. 3. elles s'elevent juſqu'à 24 et 30 pouces, ce ſont les feuilles proprement dites de la plante; je les appellerai *exterieures* quoiqu'elles ſoient dans leur origine enveloppées dans un quadruple etui de feuilles ſeminales, v. *f*, *f*, *f*, *f*, même figure, parce que celles cy ne s'elevent que très peu au deſſus de la terre: je crois que le nœud auquel eſt attaché la derniere feuille de cette enveloppe doit être regardé comme le collet de la plante qui diviſe ſa partie inferieure qui ne donne point de productions hors de terre d'avec ſa partie ſuperieure, d'où il en ſort de toute eſpéce: je n'ay du moins jamais remarqué dans cette partie inferieure, d'autre production que ces 4 petites feuilles et des racines.

3°,

3dly, Till the external leaves are eight or ten inches high, all the nourishment which the plant receives from the earth is by the roots which have ſprouted about the joint to which the bud from whence it was produced was faſtened: theſe may, therefore, be conſidered as *a ſet of roots of the firſt order*, ſee fig. 5. n. 1.

4thly, But when that time comes, the ſeminal leaves which formed the ſheath, wither, grow red, ſoon after dry up, and are finally driven away by a *ſet of roots of the ſecond order*, which appear in the places to which each of theſe ſeminal leaves were faſtened. The fourth figure ſhews the young plant deprived of its four ſeminal leaves, and provided with its ſet of roots of the ſecond order, ſee N° 2, which have taken their place.

5thly,

3°, Juſqu'au moment où les feuilles exterieures ſont hautes de 8 à dix pouces, la terre ne tranſmet de nourriture à la plante que par les racines ſorties à l'entour du nœud auquel etoit attaché le bouton qui l'a produite, et qu'on peut regarder comme un *premier ordre de racines*, v. F. 5. n. 1.

4°, Mais alors les feuilles ſeminales qui compoſoient l'enveloppe, ſe fanent, rougiſſent, peu de tems aprés ſe deſſechent, et ſont bientôt chaſſées *par un ſecond ordre de racines* qui paroiſſent à l'endroit où chacune des feuilles ſeminales etoit attachée, la fig. 4. preſente la jeune plante denuée de ſes quatre feuilles ſeminales et pourvûe de ſon ſecond ordre de racines, v. N° 2. qui a pris leur place.

5thly, Each of the *external* leaves mentioned in the ſecond article (I mean thoſe which appeared firſt) are likewiſe ſo many indications of joints in the ground; ſo much the more diſtinct, the more vigorous the leaf is; and in proportion as each of theſe leaves dries, each of the joints ſucceſſively produces a *row* of roots, which conſtitute the *third ſet*, ſee N° 3. fig. 5.

It is to each of theſe rows of roots that the joint is faſtened which is to furniſh the ſuckers which I call the ſecond productions. The fifth figure ſhews the plant without either its ſeminal or its external leaves, the joints of which are in the ground. It appears provided with its firſt, ſecond, and third ſet of roots, N° 1, 2, 3. Each row of this third ſet of roots is intended either to nouriſh the plant which is to come out of the joint which is faſtened to

---

5°, Chacune des feuilles *extérieures* mentionnées à l'article 2 (j'entends les premières ſorties) annonce auſſi un nœud en terre d'autant plus diſtinct que la feuille eſt plus vigoureuſe, et à meſure que chacune de les feuilles ſe deſſeche, chaque nœud donne ſucceſſivement un *plan* de racines qui forment le *troiſieme ordre*, v. N° 3. fig. 5.

C'eſt à chacun de ces plans de racines qu'eſt attaché le nœud qui doit donner les jets que j'appelle ſecondes productions. La figure 5 preſente la plante denuée tant de ſes feuilles ſeminales que de ſes feuilles exterieures dont les nœuds ſont en terre; elle paroit auſſi pourvûe de ſon premier ordre de racines N° 1, de ſon ſecond ordre de racines N° 2, et du 3e N° 3, chaque plan de ce 3e ordre de racines eſt deſtiné à nourrir la plante qui ſortira du bouton qui luy eſt attaché, ſi

la

to it, if the ſeaſon be favourable enough, or if either the ſeaſon or cultivation be unfavourable to the birth of this bud; in that caſe, the roots are to contribute to the nouriſhment of the plant already formed.

6thly, Let us now go back a little. Suppoſe the ſeaſon always to continue favourable, and the firſt ſhoot to be out of the earth a fortnight or three weeks after planting, conſequently the *firſt ſet* of roots formed.

At five or ſix weeks end the ſeminal leaves are expelled by a *ſecond ſet* of roots. In nine or ten weeks the firſt of the *external* leaves begins to give way to the firſt row of the third ſet of roots.

About the twelfth or fourteenth week the bud which adheres to the joint which forms the firſt row of the third ſet of roots ſwells, opens, and likewiſe appears like the ſhaft

---

la ſaiſon eſt aſſez favorable, ou bien à nourrir ſeulement la plante déja formée, ſi le défaut de ſaiſon ou de culture s'oppoſe au developpement du bouton.

6°, Revenons ſur nos pas, ſuppoſant toujours la ſaiſon favorable, et le premier jet ſorti de terre après quinze jours ou trois ſemaines, conſéquemment le *premier ordre* de racines déja formé.

A 5 ou 6 ſemaines les feuilles ſeminales cedent au *ſecond ordre* de racines. A 9 ou 10 ſemaines la premiére des feuilles *exterieures* commence à ceder au premier plan des racines du *troiſieme ordre*.

A 12 ou 14 ſemaines le bouton attaché au nœud qui forme ce premier plan de racines du 3e ordre, ſe gonfle, ſe developpe et paroit auſſi comme une fleche,

ſhaft of an arrow, ſee *f*, fig. 5. This is the immediate growth or production of the main ſtem already formed. The buds which adhere to the ſecond, third, and fourth row of the third ſet of roots likewiſe unfold and appear in regular ſucceſſion during each of the following weeks, if the rains continue. Still, however, theſe are only *ſecond productions*. The *third* are thoſe which come out of the ſecond in a month or five weeks after, *if the rains continue*, ſee *g*, fig. 5. But we muſt not forget to obſerve, with reſpect to the *ſecond productions*, that an exceeding favourable ſeaſon being neceſſary to their appearance, and this twelfth or fourteenth week (from the circumſtance of the plantation, being began in October or November) falling out in February or March, which is the uſual time of the greateſt droughts, they may be kept

---

v. *f*, fig. 5. C'eſt une production propre de la ſouche déja formée: les boutons attachés au 2^e^, 3^e^, 4^e^, &c. plan de racines de ce 3^e^ ordre, ſe developpent auſſi et paroiſſent ſucceſſivement chacune des ſemaines ſuivantes *ſi la pluye continue*, mais ce ne ſont encore que des *ſecondes productions*. Les *troiſiemes productions* ſeront celles qui un mois ou cinq ſemaines après ſortiront de ces ſecondes, v. *g*, fig. 5. *ſi la pluye continue*. Mais ce qu'il ne faut pas oublier par rapport aux *ſecondes productions*, c'eſt qu'elles ont beſoin pour paroître d'une ſaiſon très avantageuſe, et que cette 12^e^ ou 14^e^ ſemaine dans laquelle elles doivent paroître ne tombant eu egard aux plantations de Novembre et Decembre, qu'en Fevrier où Mars, tems du plus grand ſec qui ſuſpend preſque entierement la vegetation dans la terre

kept back, and only appear the May or June following, after the rainy ſeaſon has ſet in.

The fifth figure repreſents the bud (*b*) which adheres to the firſt row of the third ſet of roots, quite come out, and appearing above ground like the ſhaft of an arrow *f*. This is the ſecond production. The ſame figure likewiſe repreſents the bud (*c*) unfolded and appearing in *g*. This is the third production. It comes out of the firſt row of roots of the plant *f*, which muſt be conceived in a more advanced ſtate of vegetation than it is in the figure.

The time of, and requiſites neceſſary for, the ſucceſſive appearances of all theſe different vegetations, ſeem to me ſo many proofs of the fundamental part of my method, to wit, *the neceſſity of planting in the only ſeaſon fitted to accelerate and preſerve them.*

The

---

decouverte, ces *ſecondes productions* retenües dans la terre ne paroîtront donc qu'en May ou Juin ſuivant, lorſque les pluyes ſeront decidées.

La figure 5 preſente le bouton (*b*) du premier plan du 3e ordre de racines developpé et paroiſſant comme une pointe de fleche *f* hors de terre que nous ſuppoſons *a*. C'eſt la ſeconde production. La même figure preſente auſſi le bouton (*c*) developpé, et paroiſſant en *g*. C'eſt la 3e production, elle ſort du premier plan de racines de la plante *f* qu'on doit ſuppoſer plus avancée qu'elle n'eſt repreſentée ici.

Le tems et les conditions du developpement des ces differentes productions me paroiſſent autant de preuves de la partie fondamentale de mon ſyſteme, ſçavoir, *la neceſſité de planter dans l'unique ſaiſon qui ſoit propre à hâter et entretenir ces developpements.*

The nine months during which you may reaſonably look out for a continuation of rain are from the 15th of May to the 15th of February. The progreſſion of the rain keeps, as it were, pace with that of your canes when they are planted in May. Moderate in the beginning, more conſiderable afterwards, very copious when your canes are big enough to have nothing to fear from them, they leſſen gradually as the time of the crop draws near.

7thly, Whenever I ſtubbed up the ſtumps of a plant which had been ten months in the ground, I always found a portion of the woody part of the plant very ſound: the medullary part was rotten. This made me think that every *planted* cane continued, for the whole time of its duration, to derive its nouriſhment not only from the roots of the *ſecond* and *third orders* (which may be looked upon

---

Les neuf mois où l'on peut raiſonnablement eſpérer une continuation de pluye, ſont depuis le 15 May juſqu'au 15 Fevrier. Les pluyes augmentent pour ainſi dire avec vos cannes plantées en May; foibles d'abord, plus conſiderables enſuite, et par averſes lorſque vos cannes ſont aſſez grandes pour ne les plus redouter, ceſſant enfin par degrés à meſure que le tems de la coupe approche.

7°, Lorſque j'ay deraciné des ſouches qui provenoient d'un plan mis en terre depuis dix mois, j'ay toujours trouvé très ſaine une portion de la partie ligneuſe du plan; la partie medullaire etoit pourrie; et j'ay cru que chaque canne *plantée* continuoit donc pendant qu'elle ſubſiſtoit à tirer ſa nourriture non ſeulement du *ſecond* et du *troiſieme* ordre de racines qu'on peut regarder comme ſes racines propres,

upon as its own roots) but likewiſe from thoſe of the *firſt*, that is, from thoſe which had ſprung about the joint to which the button which produced it was faſtened. Fig. 6. repreſents an entire cane (*a*) ſprung from the plant *b*, the woody part *c c*, was as ſound at the end of ten months as when it was put into the ground: the medullary part was entirely rotted as was likewiſe the herbaceous, *dddd*, which forms the top of the head. There is no doubt but the medullary part affords the bud the ſame nouriſhment as the lobes of almonds do to to the germ which they contain.

8thly, Whenever I ſtubbed up the ſtumps of a plant which had been thirteen months in the ground, and the canes of which had been cut a month or two before, I always found all the woody part of the plant which belonged to the ſtump rotten, the roots of the plant dried up,

---

pres, mais encore du *premier* ordre de racines, c'eſt à dire de celles qui s'etoient formées à l'entour du nœud auquel etoit attaché le bouton qui l'a produite. La fig. 6. preſente une canne entiere *a* provenant du plan *b*, dont à dix mois la partie ligneuſe *c c* etoit auſſi ſaine que lors qu'on l'avoit miſe en terre, la partie medullaire etoit entierement pourrie, ainſi que la partie herbacée *dddd* qui compoſe la partie ſuperieure de la tête: la partie medullaire fournit ſans doute au bouton la nourriture que les lobes des amandes fourniſſent au germe qu'elles contiennent.

8°, Lorſque j'ay deraciné des ſouches qui provenoient d'un plan mis en terre depuis 13 mois, et dont on avoit coupé les cannes depuis un ou deux mois, j'ay toujours trouvé pourrie toute la partie ligneuſe du plan d'ou provenoit la ſouche, les

up, each of the young rattoons provided with its *ſecond* and *third* ſet of roots, and each of theſe *rattoons* faſtened in the ground to the joint of one of the canes which had been cut. This joint being ſtill green, I concluded, from the ſame kind of reaſoning, that theſe rattoons likewiſe drew their nouriſhment not only from their own proper roots, but likewiſe from thoſe of the joint they had come out of, juſt as the planted cane draws it both from its own roots, and from thoſe of the joint it comes from.

But as the plant has been always found rotten ſoon after the cane which it had produced had been cut, I began to ſuſpect, that canes of all ſorts, not only the *planted* but the *rattoons* likewiſe, never draw any nouriſhment but from

---

les racines de ce plan deſſechées, chacun des nouveaux rejettons en poſſeſſion de ſon *ſecond* et *troiſieme* ordre de racines, et chacun de ces rejettons attaché dans la terre à un nœud d'une des cannes qu'on avoit coupées, ce nœud etant encore verd, j'ay conclu que les *rejettons* jouiſſoient auſſi non ſeulement de leurs propres racines, mais encore de celles du nœud dont ils etoient ſortis, comme la canne plantée jouit de ſes propres racines et de celles du nœud dont elle tire ſon origine.

Mais comme le plan, ſuivant ce qu'on vient de voir s'eſt toujours trouvé pourri, peu de tems après que la canne qu'il avoit produite a été coupée, j'ay ſoupçonné que toutes les cannes non ſeulement *plantées* mais même *rejettons* ne joüiſſoient jamais que des trois ordres de racines dont j'ay déja parlé: ce qui ſe-

roit

from the three ſets of roots of which I have ſpoken. This, if true, is a ſtrong argument againſt the pretended antiquity of the ſtools, which are ſaid to be ten, fifteen, and even twenty years old. It is alſo a very powerful argument in favour of my principle of the inutility of replanting when the ſtump is not raiſed above the ground, ſince grant my ſuſpicion to be grounded, and it follows, *that the oldeſt of the roots of a ſtool, the canes of which are cut every year, cannot be above two years old.*

9thly, In order then to clear up ſo important a point, I ordered a ſtool of canes, which had been planted about four years before, had been regularly cut every year, and for the laſt time about ſix months before, to be ſtubbed up. The rattoons were very fine; there were upwards of eighty of them, ſmall and great (hardly a ſixth part of this number uſually ſucceeds); the *group*, notwith-

---

roit bien contraire à la vetuſté pretendue des ſouches qu'on dit être de 10, 15 et 20 ans: et ſeroit un grand argument en faveur de mon principe de l'inutilité de replanter, lorſque la ſouche n'eſt pas elevée au deſſus de la terre; puiſque dans le cas où mon ſoupçon ſeroit juſte, *la plus vieille de toutes les racines d'une ſouche dont on coupe les cannes tous les ans, n'auroit pas au dela de deux années.*

9°, Pour eclaircir un point auſſi important j'ay fait deraciner une ſouche de cannes plantées depuis quatre ans, coupée reguliérement chaque année, et pour la derniere fois depuis ſix mois: les rejettons etoient fort beaux, il y en avoit plus de 80 tant grands que petits (il en reuſſit rarement la ſixieme partie) la touſſe

notwithſtanding, was not above ten inches in diameter when it came out of the ground. In order not to injure it, I ordered ſix inches of the ſurrounding earth to be taken up with it. When I had had it waſhed and freed from all extraneous earth, I found no veſtiges of any wood but that of the canes which had been laſt cut: I then took each rattoon apart, and found it faſtened to a joint of theſe laſt canes, which joint was ſtill green. I examined the remains of each of theſe laſt canes, and found the kind of bulb, ſee *u*, fig. 1. by which they had been faſtened to ſome joints of canes of the preceding year, entirely *dried up*. I met with no appearance of this laſt cane, which conſequently had rotted, and in place of it there was nothing to be ſeen but dry roots; roots take a great while to rot.

Conclude

touffe n'avoit cependant pas au dela de dix pouces de diametre à ſa naiſſance hors de terre; pour ne la point endommager, j'ay fait cerner et enlever avec elle ſix pouces de terre à l'entour, et après l'avoir lavée et debarraſſée de toute ſa terre, je n'ay vu de trace d'aucun autre bois que de celuy des dernieres cannes coupées; j'ay detaché chaque rejetton ſéparément, et j'ay vu qu'il etoit attaché à un nœud de ces dernieres cannes, et que ce nœud etoit encore verd; j'ay ſuivi les reſtes de chacune de ces dernieres cannes, et j'ay vu entiérement *deſſechè* l'eſpece d'ombilic (*v u*, fig 1.) par lequel ils etoient attachés aux nœuds de quelques cannes de l'année précédente; je n'ay vu aucune apparence de cette ancienne canne, qui par conſéquent etoit alors pourrie, on ne voyoit à ſa place que des racines deſſechées, les racines ſont aſſez long tems à pourrir.

Conclude we then, as I ſuſpected, that the rattoons as well as the planted canes derive nouriſhment only from the three orders of roots of which I have ſpoke, with this difference only, that the firſt order of roots belonging to the *planted canes* comes from the plant which is put under ground; whereas that of the rattoons comes from the part of the cut canes which continue in the ground after they have been cut, and which rots the following year ſoon after the ſucceeding rattoons have appeared, ſo that the third order of roots of a cane which has been juſt cut becomes the firſt order of thoſe of the rattoon it is about to produce; which firſt order, as well as the ſecond, will rot the following year, when new rattoons ſhall have taken the place of thoſe which ſhall then be cut.

The

Concluons comme je l'avois ſoupçonné que les rejettons ne jouiſſent comme les cannes plantées que des trois ordres de racines dont j'ay parlé, avec cette difference que le premier ordre de racines des cannes plantées provient du plan mis en terre, et que celuy des rejettons provient de cette partie des cannes coupées qui reſte dans la terre, partie qui pourrira l'année ſuivante peu de tems après que les rejettons ſubſequens auront paru; de ſorte que le troiſieme ordre de racines d'une canne qu'on vient de couper, devient le premier ordre de racines du rejetton qu'elle va produire, lequel premier ordre pourrira l'année ſuivante ainſi que le ſecond, aprés que de nouveaux rejettons auront ſuivi la coupe qu'on aura faite des precedents.

The idea, therefore, of having ſtumps of fifteen or twenty years ſtanding muſt be given up, ſince it is proved, that the oldeſt are thoſe of the laſt year; but this idea being given up, it can never be aſſigned as a reaſon for re-planting ſo often. It will be ſufficient, therefore, to replant annually a ſixth of one's land: to ſpeak more correctly, it will always be uſeleſs to replant, *as long as the ſtump is not raiſed above ground, and the ground about it is raiſed as it ought to be by annual and well-directed labours.* I ſay, the ground about muſt be annually raiſed, for otherwiſe it is impoſſible but that the feet of the negroes and cattle muſt harden and render it impervious to the roots which are to make their way every year.

It likewiſe appears of what conſequence it is to cut the canes in the ground in order to prevent the ſtump from

---

Il faut donc renoncer à la pretention d'avoir des ſouches de 15 et 20 ans, les plus vieilles ſont de l'année precedente, et cette prétendue vetuſté des ſouches etant demontrée fauſſe, elle ne doit plus être une raiſon pour replanter auſſi ſouvent; il ſuffira donc de replanter annuellement la ſixieme partie de ſa terre, ou pour mieux dire, il ſera toujours inutile de replanter *lorſque la ſouche ne ſera pas élevée au deſſus de la terre et que par des labours annuels et bien faits on aura ſoin de ſoulever celle qui l'environne*, que les pieds des negres et des beſtiaux quand on la travaille ne manqueroient pas d'affaiſſer à la longue, et de rendre preſque impénétrable aux nouvelles racines qui doivent ſe former chaque année.

On voit auſſi combien il eſt eſſentiel de couper les cannes dans la terre, afin

from riſing above ground, conſequently how bad the method of moulding up the ſtumps, thought by ſo many people to be ſo good, really is; ſince it raiſes the ſtump every year, and ought, therefore, only to be adopted with reſpect to thoſe pieces one propoſes to replant the next year: then, indeed, it is excellent, but in that ſingle caſe only.

Hence likewiſe it appears, why rattoons are forwarder at the twelvemonth's end than planted canes are at the end of thirteen. The firſt order of the roots of the rattoons is in its full vigour at the inſtant of the crop; that of the planted canes is ſeldom ſo at a month's end.

We likewiſe ſee why the rattoons of canes that have been cut at the end of ten, eleven, or twelve months, are always finer than thoſe of canes which have ſtood fifteen or ſixteen months; the woody part of the latter being much

---

d'empêcher la ſouche de s'élever; et combien eſt mauvaiſe la maxime de rechauſſer, que tant de gens trouvent ſi bonne, qui eleve cependant tous les ans la ſouche, et qu'on ne devroit ſuivre que par rapport aux piéces qu'on ſe propoſe de replanter l'année ſuivante, elle eſt excellente alors, mais dans ce cas ſeulement.

On voit auſſi pourquoy les rejettons a douze mois ſont plus avancés que les cannes plantées ne le ſont à treize: le premier ordre de racines des rejettons eſt dans toute ſa force au moment de la coupe, celuy de cannes plantées l'eſt rarement au bout d'un mois.

On voit auſſi pourquoy les rejettons des cannes coupées a dix, onze, et douze mois ſont toujours plus beaux que ceux des cannes coupées a 15 et 16 mois, le

much harder is exactly in the same case as the plant, the first joints of which (as I observed before) produced no shoots, except the season happened to be remarkably favourable.

Hence likewise we see, why one never gets any fine rattoons from the grounds which are called exhausted: the planted canes in them are cut at the end of the fifteenth or sixteenth month; at which time the part of their wood which remains under ground, and out of which the rattoons come, is extremely hard. Besides, this is done in February, March, or April, months, as may be seen from the account I have given before of the seasons, not likely to produce miracles of vegetation.

Hence, finally, we see, why it is not at all to be wondered at, that the rattoons which I cut before the time should

---

bois de celles cy beaucoup plus dur est dans le cas du plan dont j'ay remarqué cy dessus que les premiers nœuds qui etoient les plus durs, ne donnoient point de jets à moins d'une saison singulierement favorable.

On voit aussi pourquoy l'on n'a jamais de beaux rejettons dans ces terres qu'on appelle epuisées; on y coupe les cannes plantées a 15 et 16 mois, la partie de leur bois qui reste en terre, et d'ou proviennent les rejettons est alors très dure, et d'ailleurs cette coupe se fait en Fevrier, Mars, et Avril, et l'on peut voir par le tableau de la pluye, p. 217. que ces trois mois ne sont pas propres à produire des miracles de végétation.

On peut conclure aussi qu'il n'est pas etonnant que les rejettons dont j'ay toujours anticipé la coupe aient été (comme je l'ay éprouvé) ceux qui se soient le

ſhould have been what I ever found them to be, thoſe which ſtood the beſt; that nothing, on the contrary, ſo much improves a piece of rattoons as cutting them before the time; and that, therefore, this operation (a neceſſary one when my method is followed) is not without its attendant advantage, which perhaps much leſſens the loſs which I have ſuppoſed to ariſe from it in page 213.

10thly, Having waſhed and gently ſcraped as far up as their beginning (that is, to the kind of bulb I deſcribed) two rattoon canes, ſix months old; the one taken out of a damp, the other out of a very dry ſoil; the one with fourteen joints above ground, on a length of twenty-eight inches; the other with only two joints, on a length of two inches; I found that the cane which had fourteen joints above ground, had only five rows of roots of the *third order* on a length of an inch and a half under ground;

---

mieux ſoutenus; que rien n'eſt plus capable de reparer une piece de rejettons que d'en anticiper la coupe; et qu'ainſi l'anticipation des coupes neceſſaire dans mon ſyſteme, n'eſt point ſans un avantage qui diminue peut-être bien conſidérablement la perte que j'ay ſuppoſée, p. 213.

10°, Après avoir lavé et grattè legerement juſqu'à leur origine (juſqu'à cet eſpéce d'ombilic dont j'ay parlé) deux cannes rejettons de ſix mois, l'une priſe dans un terrein humide, l'autre dans un terrein très ſec, l'une ayant hors de terre quatorze nœuds dans une longueur de 28 pouces, l'autre ayant ſeulement cinq nœuds dans une longueur de deux pouces, j'ay vu que la canne qui avoit quatorze nœuds hors de terre, n'avoit en terre que cinq plans de racine du *troiſieme ordre* dans une longueur

ground; whereas the cane which had only five joints out of the ground had fourteen rows of roots, likewiſe of the *third order*, on the ſame length as the others.

This obſervation proves, that to the time of the canes jointing, that is, to the appearance of one of its joints above ground, the drying of each external leaf is conſtantly followed by a row of roots of the third order. One ſees too, why canes that are in moiſt ſoils joint out of the ground at the three months end; but have then only four or five rows of roots of the third order, diſtant from each other three, four, and five lines under ground; whereas, on the contrary, in dry lands, or, what comes to the ſame, in a ſoil remarkably impoveriſhed for want of cultivation, the canes do not joint above ground before the five months; but then they have under ground

---

longueur d'un pouce et demi, et que la canne qui n'avoit que cinq nœuds hors de terre, avoit en terre quatorze plans de racines auſſi du *troiſieme ordre* et dans la même longueur.

Cette obſervation prouve que juſqu'au tems où la canne noue c'eſt à dire laiſſe voir un nœud hors de terre, le deſſechement de chaque feuille exterieure, eſt toujours ſuivi d'un plan de racines du troiſieme ordre; et l'on voit pourquoy dans les terreins humides, les cannes nouent hors de terre a 3 mois, mais alors elles n'ont en terre que 4 à 5 plans de racines du troiſieme ordre diſtants les uns des autres de 3, 4, et 5 lignes; dans les terres ſeches au contraire, ou (ce qui eſt egal) ſinguliérement affaiſſées par le defaut de culture, les cannes ne ſont nouées hors de terre qu'à cinq mois, mais alors elles ont en terre quatorze à quinze

ground fourteen or fifteen joints or rows of roots, distant from each other only a line, and sometimes less; the joints, therefore, of the canes, of a dry or ill cultivated soil, are as many in number as those of a moist and fruitful soil; but the two differ in this: the greater part of the former are short, small, and in the ground; whereas the greater part of the last are thick, long, and above ground.

It is therefore the excellence or the defect either of the season, or the cultivation, which keeps back and bastardizes the one sort, which hastens and makes the other thicker: chuse, therefore, that season for planting in which the greatest possible succession of rain shall force *out* of the grounds those joints which, in a drier season, would only have formed a quantity of roots within it, the

---

quinze nœuds ou plans de racines distants les uns des autres d'une ligne seulement et quelque fois moins: les nœuds des cannes d'un terrein sec ou mal cultivé sont donc égaux en quantité à ceux des cannes d'un terrein humide ou fertile, mais ils différent en ce que la plus grande partie des uns sont courts, petits, et dans la terre; le plus grand nombre des autres sont gros longs et hors de terre.

C'est donc la bonté ou le defaut de la culture ou de la saison qui retient et abâtardit les uns, precipite et groffit les autres; choisissez donc pour planter la saison ou la plus grande continuité de pluye possible, forcera le plutôt à se developper hors de terre, les nœuds qui dans une saison plus seche formeroient uniquement en terre, une quantité considérable de racines dont l'inutilité est visible

the uſeleſſneſs of which appears from the ſtate of the lands which are burthened with them.

The firſt reaſon for planting in May or June (ſee obſervation the ſixth, p. 227.) reſpected the coming up of the different productions, firſt, ſecond, &c. in general; that I have juſt given regards the firſt appearances of each particular production. We will next conſider if my method is equally favourable to thoſe which are to give the plant all the degree of perfection it is capable of acquiring.

Hiſtory

---

viſible par l'etat des plantes qui en ſont affligées.

La premiere raiſon de planter en May et Juin, dont j'ay parle obſ. 6. p. 227. intereſſoit la ſortie des différentes productions en général premiere, ſeconde, &c. la ſeconde raiſon dont je viens de parler intereſſe les premiers developpemens de chaque production en particulier, voyons ſi mon ſyſteme favoriſe egalement ceux qui doivent donner à la plante toute la perfection dont elle eſt ſuſceptible.

Hiſtoire

History of the joints of the cane above ground.

With reſpect to the joints of the cane, there are two points of equal conſequence to be conſidered, the number and the quality.

With regard to number, the calculation of it, in both the methods, depends upon ſo many conſiderations, that I think myſelf obliged to reduce the queſtion to its moſt ſimple ſtate, by barely declaring, that I now cut all my canes every year, inſtead of only cutting three-fourths of them, as I uſed to do when I purſued the other method. Thoſe, however, who wiſh to know more of it, may ſee in another part of this paper the only calculation the matter is capable of.

As

Hiſtoire des nœuds de la canne hors de terre.

Il ſe preſente à l'égard des nœuds de la canne deux points à conſiderer auſſi eſſentiels l'un que l'autre, le nombre et la qualité.

Quant au nombre le calcul qu'on peut en faire dans les deux ſyſtemes, eſt ſubordonné à tant de ſuppoſitions que je crois devoir ſimplifier la queſtion, en expoſant que je coupe maintenant toutes mes cannes chaque année au lieu den couper ſeulement les trois quarts comme je faiſois, lorſque je ſuivois l'autre ſyſteme. Voyez cependant dans ſon lieu, l'unique eſpece de calcul dont je croye la matiere ſuſceptible.

As to the quality of the joints; this, I think, is to be decided by the hiſtory of them, to which hitherto ſcarce any attention has been paid, though the ſlighteſt would have been ſufficient to have ſhewn the abſurdity of the received ideas concerning the age which muſt be allowed the canes, in order for them to arrive at perfect maturity.

At the end of the third month, ſometimes later, as this depends upon the ſoil and ſeaſon, nothing yet appears but a head covered with leaves: ſee figure 8. from *a* to *z*, which is a ſmall ſheath containing a number of white leaves which come out by degrees. The leaf *b*, ſee fig. 9, falls at length, and diſcovers a firſt joint above ground. From that inſtant to the time of its full growth it acquires four or five joints every month: theſe alſo depend

---

Quant à la qualité des nœuds il me ſemble qu'elle peut être decidée par leur hiſtoire à laquelle on n'a fait juſqu'à preſent qu'une mediocre attention, quoique la plus legere eut ſuffi pour demontrer la fauſſete des idées qu'on a eu juſqu'à preſent ſur l'age qu'il faut donner aux cannes, pour leur procurer une maturité parfaite.

A trois mois quelquefois plus tard (ſuivant la terre et le tems qu'il a fait) la canne ne preſente encore qu'une tige herbacée garnie de feuilles, v. fig. 8, depuis *a* juſqu'à *z* qui eſt un petit rouleau qui renferme une quantité de feuilles blanches qui doivent ſe developper par degrés; la feuille *b*, v. fig. 9, tombe enfin et laiſſe voir un premier nœud hors de terre. De ce moment juſqu'à celuy où elle a pris tout ſon accroiſſement elle augmente chaque mois de quatre à cinq nœuds

pend upon the weather and ſoil, and are longer or ſhorter, thicker or thinner, according as thoſe are more or leſs favourable. One may ſee (figure 1, from *i* to *k*) the effects of a continued drought when it ſets in in February, and laſts till May or longer. The joints are ſtunted, and inſtead of being an inch and a half or two inches long, like thoſe from *b* to *i*, which come out in a favourable ſeaſon, ſome of them are hardly two lines, and ſome even leſs. When the rains begin again and continue, the joints are longer again (ſee *k* to *l*) and like the firſt from *b* to *i*. The effects of the dryneſs of the ſoil are exactly ſimilar to thoſe of the weather. I once had a cane in my plantation worthy a place in a collection of natural hiſtory: it was of the thickneſs of a pea, and only three inches long; notwithſtanding which

---

nœuds plus ou moins gros, plus ou moins longs, c'eſt auſſi ſuivant le tems et le ſol, ou peut voir fig. 1. depuis *i* juſques à *k* l'effet d'un ſec tres vif lorſqu'il commence avec le mois de Fevrier et qu'il continue juſqu'en May ou plus long tems; les nœuds ſont etranglés et au lieu d'avoir un pouce et demi ou deux pouces de long, comme les nœuds depuis *b* juſqu'a *i* produits dans une bonne ſaiſon, quelques uns de ceux produits dans le tems du ſec, ont a peine deux lignes, d'autres en ont moins: lorſque les pluyes recommencent et continuent, les nœuds qui ſortent ſont plus longs, comme on les voit depuis *k* juſqu'a *l*, et tels que les premiers depuis *b* juſqu'a *i*. L'effet de l'avidité du ſol eſt exactement le même que celuy de la vivacité et de la longueur du ſec: j'ay vu chez moy dans une eſpéce de tuff près d'une carriére, une canne digne d'être miſe dans le cabinet d'un curieux, elle etoit groſſe comme une plume à ecrire, longue de trois pouces, et n'en

which it had its two and twenty joints very distinct. I sent it in a letter to a person who might have sent me in exchange some six feet long; which, however, would not have had above twenty-two joints any more than mine, if the first joints of both had come out of the earth at the same time.

The first joint, which comes out either at the third, fourth, or fifth month, always keeps in its first place near the earth, see *a*, fig. 9.; out of this first comes the second, see *b*, fig. 10.; and out of the second a third, after the leaf *cc* has dried, and is fallen off like the leaves *aa*, *bb*. Each week produces its joint, or very nearly: a leaf likewise dries and falls off pretty nearly every week. A cane of thirty-two joints, supposé fit to cut, has from five to eight and twenty of them which have lost their leaves; the next five or six still have them, but withered and

---

n'en avoit pas moins ses 22 nœuds tres distincts; je l'envoiai dans une lettre à une personne qui auroit pu m'en envoyer en echange quelques autres de 6 pieds de long et qui dans cette longueur n'auroient eu que 22 nœuds comme la mien ne si elles avoient noué hors de terre en même tems.

Le premier nœud qui paroit soit à 3 soit à quatre ou à cinq mois, reste toujours à sa même place près de la terre, v. *a*, fig. 9. de celuy la sort le second, v. *b*, fig. 10. du second le troisieme, apres que la feuille *c*, *c*, sera dessechée et tombée comme les feuilles *aa*, *bb*, même figure, chaque semaine fournit environ son nœud; il se dessèche et tombe donc à peu près une feuille par semaine; dans une canne de 32 nœuds, je suppose, bons à couper, on en voit 25 à 28 depouillés naturellement de leurs feuilles, et cinq à six autres garnis encore de

and ready to fall off: the remaining joints, ſurrounded with green leaves, form the head, which one takes care to cut off after the laſt leaf has withered. The bare recital of facts ſeems fully to prove that the withering and fall of a leaf is the only criterion (and a ſufficient one it is) of the maturity of the joint to which it adhered; and that the eight laſt joints of two canes, which are cut the ſame day, have exactly the ſame age and the ſame degree of ripeneſs, notwithſtanding one of the canes themſelves may be fifteen, and the other only ten months old. My reaſoning is further confirmed by the experiment repeatedly made on two equal quantities of canes, cut the ſame day in pieces of a different age; it was evident, that each joint of the cane, of a ſuppoſed growth of ten months, contained the ſame quantity of ſugar as that of a cane of the ſuppoſed growth of fifteen.

The

---

leurs feuilles deſſechées prêtes a tomber; les nœuds ſuivant, garnis de feuilles vertes, forment la tête qu'on a ſoin de couper après la derniere feuille deſſechée: la ſeule expoſition des faits me ſemble demontrer que le deſſechement et la chute d'une feuille, eſt l'unique preuve (et preuve ſuffiſante) de la maturité du nœud au quel elle etoit attachée: et que les huits derniers nœuds de deux cannes coupées le même jour ſont exactement du même age et de la même maturité, quand bien même l'une de ces cannes auroit quinze mois et que l'autre n'en auroit que dix; preuve de raiſonnement confirmée par des expériences réiterées de deux quantités egales de cannes, priſes dans des piéces d'un age different, et coupées le même jour, par leſquelles il conſte que chaque nœud de cannes pretendües de dix mois contient autant de ſucre que chaque nœud de cannes pretendües de quinze.

La

The neceſſity, therefore, which my method lays me under of cutting my planted canes at the twelvemonth's end, and my rattoons at eleven, has nothing in it which contradicts the proper idea which ought to be entertained of the abſolute maturity of this plant. This is decided by experience, and the hiſtory of its joints.

With regard to its relative maturity, that which is of conſequence to the ſugar, this does not depend on the age, but on the ſeaſon. In February, March, and April, all the canes, whatever be their age, are as ripe as the nature of the ſoil ever allows them to be, and accordingly I never fail to make the greateſt part of my ſugar at this ſeaſon.

It will be of uſe to obſerve, that in the ſame week in February I cut in a piece which had been planted ten months a quantity of canes ſufficient to yield me four thouſand

---

La neceſſité ou je ſuis dans mon ſyſteme de couper mes cannes plantées à douz mois et mes réjettons a onze, n'a donc rien de contraire à l'idée qu'on doit ſe faire de la maturité abſolüe de cette plante, maturité decidée par l'expérience auſſi bien que par l'hiſtoire de ſes nœuds; quant à ſa maturité relative, celle qui intereſſe le ſucre elle n'eſt pas l'effet de l'age mais de la ſaiſon, en Fevrier, Mars, et Avril, toutes les cannes de quelque age quelles puiſſent être, ont la perfection de maturité dont la qualité du terrein les rend ſuſceptibles, et je ne manque pas de faire la plus grande partie de mon ſucre dans cette ſaiſon.

Il ne ſera pas inutile d'obſerver que j'ay coupé dans la même ſemaine de Fevrier, dans une piece agée de 10 mois, la quantité de cannes neceſſaires pour me

thouſand gallons of juice, and exactly the ſame quantity in a piece which had been planted fifteen months. If any body ſhould chance to repeat this experiment, they ſhould be careful to chuſe the ſame kind of ſoil, the ſame expoſition, and the ſame time of year. The juice of the piece which was ten months old was a little greeniſh, that of the piece of fifteen months was exceeding brown. The four thouſand gallons of juice from each of the pieces gave me the ſame quantity of very fine ſugar, which proves that each joint of canes ſuppoſed to be nine months old contains juſt as much ſugar as each joint of a cane to be fifteen months old.

It likewiſe proves, that all the joints, whoſe leaves have dried and are fallen off, have acquired that maturity which I call abſolute.

It

---

me donner quatre mille galons de *veſou* ou jus, et la même quantité dans une piece agée de 15 mois (ſi l'on vouloit reiterer la même experience il faudroit choiſir dans les deux piéces a peu près la même qualité des terre et la même expoſition comme on choiſirait le même tems) le veſou de la piece agée des 10 mois etoit un peu verdâtre, celuy de la piece de 15 mois etoit fort brun; les 4000 galons de veſou de l'une et de l'autre piece m'ont donné la même quantité de très beau ſucre. Ce qui prouve que chaque nœud de cannes pretendües de dix mois contient autant de ſucre que chaque nœud des cannes prétendües de quinze.

Cela prouve auſſi que tous les nœuds dont les feuilles ſont deſſechées et tombées ont acquis cette maturité que j'appelle abſolüe.

It likewiſe proves, that it is not the age of the canes but the dryneſs of the weather, which increaſes from January to April, which is the cauſe that in January four hundred gallons of juice commonly yield forty-eight gallons of ſugar and molaſſes, one with another; in February from fifty-ſix to ſixty-four; in March from ſixty-four to ſeventy-two; in April ſometimes eighty; after which period the ſugar ferments, and even burns when the refiner happens not to be very expert at his buſineſs. Hence I concluded, that the greateſt perfection of relative maturity to which my canes could arrive was when the juice of them was made up of four parts water, and one part conſiſting of part ſugar and part molaſſes.

This laſt obſervation likewiſe proves, that the colour of the juice has nothing to do with either the quantity or

---

Cela prouve auſſi que ce n'eſt pas l'age des cannes mais le ſec qui augmente de Janvier en Avril qui fait qu'en Janvier 400 gallons de veſou rendent ordinairement 48 gallons tant ſucre que melaſſe, en Fevrier de 56 a 64; en Mars de 64 a 72; en Avril quelquefois 80. Après quoy le ſucre mouſſe, brule même, ſi le raffineur n'a qu'une routine; de ce dernier point j'ay conclu que la plus grande perfection de maturité *relative* ou mes cannes puſſent atteindre, etoit lorſque leur jus contenoit quatre parties d'eau et une tant de ſucre que de melaſſe.

Cela prouve auſſi que la couleur du veſou n'intereſſe ni la quantité ni la qua-

lité

or the quality of the ſugar, but may ſerve as an indication of the manner in which it is to be made. I ſhould think an object of this importance would not be unworthy the attention of ſome very great chemiſt.

Other obſervations have ſhewn me that in canes which are perfectly ripe, the quantity of the ſugar is equal to that of the molaſſes.

Let us now examine ſome other circumſtances relative to the growth of the cane, and particularly that of its duration.

The

---

lité du ſucre, mais elle ſert d'indice pour la traiter d'une façon ou d'un autre, et il me ſemble qu'un objet de cette importance ne ſeroit pas indigne de l'etude d'un très grand chimiſte.

D'autres obſervations m'ont prouvé que dans les cannes parfaitement mures la quantité du ſucre eſt egale à celle de la melaſſe.

Examinons quelqus autres circonſtances de l'accroiſſement de la canne et ſur tout celle de ſa durée.

The account of the cane in different ſoils, together with that of the different degrees and different kinds of growth they give to it.

We are not to form our ideas of what a plant is in a country favourable to it, from what we ſee it in one where all it reaps from the care beſtowed on it, is the lengthening out of a wretched exiſtence uſeleſs to every purpoſe but curioſity. The cane to be met with in the hot-houſes of Europe is the bare ſhadow of the American cane. Let us not then eſtimate the natural duration of the one by the artificial, and in ſome meaſure only apparent duration of the other: I with juſtice call it an apparent duration; for, if the European cane acquires only

---

Hiſtoire de la canne dans les différentes eſpèces de terre, des divers degrés, et de l'eſpèce d'accroiſſement qu'elle y acquiert.

Il ne faut pas juger de l'hiſtoire d'une plante dans un climat qui favoriſe tous ſes developpemens, par ſon état dans un pais ou elle ne retire d'autre fruit des ſoins qu'on luy donne, que la prolongation d'une triſte exiſtence, inutile à tous autres egards que celuy de la curioſité. La canne qu'on voit dans les ſerres en Europe n'eſt que l'ombre de celle d'Amerique; ne jugeons donc point de la durée naturelle de l'une, par la durée artificielle et en quelque façon apparente de l'autre; je dis, apparente, car ſi la canne d'Europe ne croît, je ſuppoſe que d'un

only a ſingle joint each year, fifty-two years of exiſtence in Europe are not more than fifty-two weeks exiſtence in America[a].

RECITAL OF FACTS.

1ſt, I have never ſeen, either in my own plantation or that of any other perſon, a cane which had more than

(a) When I firſt made this ſuppoſition, I rather conjectured what muſt be than what I knew exactly; but ſince that time, Mr. THOUIN, of the King's Botanic Garden at Paris, has rid me of the little anxiety I could not help feeling at having ventured an aſſertion of the truth of which I was not accurately ſure. He ſhewed me a cane which, *he believes*, to have been planted twelve years ago: it has thirty joints. In order to be convinced that it has grown at the rate of two joints and a half a year, one ſhould be fully ſatisfied that it was planted twelve years ago; but he likewiſe ſhewed me one which *he knows* was brought from America in a pot ten years ago, and this has only two joints out of the ground. Conclude we then, as I ſaid before, that, in order to know a plant thoroughly, we ſhould ſtudy it in the climate to which it belongs.

forty

---

d'un nœud par chaque année, 52 années d'exiſtence en Europe n'équivaudroient qu'à 52 ſemaines d'exiſtence en Amerique *.

EXPOSONS DES FAITS.

1e obſervation, Je n'ay jamais vu chez moi ni ailleurs de cannes qui euſſent

* Lorſque je hazardois cette ſuppoſition je ne faiſois qu'imaginer ce qui pouvoit être; Mr. THOUIN, du Jardin du Roy à Paris, m'a mis en etat d'apprecier une idée ſur laquelle je n'etois pas ſans une eſpéce d'inquietude; il m'a fait voir une canne *qu'il croit* plantée il y a douze ans: elle a trente nœuds; pour etablir qu'elle a cru a raiſon de deux nœuds et demi par an il faudroit être certain qu'elle a *été* plantée il y a douze ans; mais il m'a fait voir auſſi une canne *qu'il ſcait* avoir *été* apportée d'Amerique dans un pot il y a deux ans, elle n'a que deux nœuds hors de terre: concluons du moins comme je l'avoir dit que pour connoitre une plante, il faut la ſuivre dans le climat qui lui eſt propre.

forty or fifty uſeful joints (I do not ſpeak of thoſe of the head); nor have I often met with this number upon any, the length of which fell ſhort of ſeven, or exceeded nine feet.

2dly, I have never ſeen this length but either in a new ſoil, or in a ſoil the moiſteſt that could be without being quite drowned; that is to ſay, in a ſoil the moſt favourable to the quickeſt and greateſt vegetation of the cane.

3dly, In a ſoil of this kind I have always ſeen the firſt joint out of the ground at the three months end; if there had been frequent ſhowers and no hard rains, at the end of two and a half.

4thly, Even in ſuch a ſoil I have never cut canes at the thirteen months end without finding many of them rotten

---

au dela de 46 nœuds utiles (je ne parle pas de ceux de la tête) et j'ay rarement vu cette quantité de nœuds dans une longueur moindre de ſept pieds, et plus conſiderable que neuf.

2e obſervation, Je n'ay jamais vu cette longueur ailleurs que dans un terrein neuf, ou le plus humide ſans être noyé, c'eſt à dire dans le terrein le plus favorable au plus prompt et au plus grand accroiſſement de la canne.

3e obſervation, Dans un terrein de cette eſpéce, j'ay toujours vu la canne nouée hors de terre, à trois mois, quelquefois à deux et demi, s'il y avoit eu des ondées frequentes ſans averſes.

4e obſervation, Je n'y ay jamais coupé les cannes à 13 mois ſans en trouver beaucoup de pourries ou preſque deſſechées, pourries et couchées, ſi l'année avoit

rotten or almoſt dried up; rotten and laid if there had been much rain in the year; almoſt withered, though ſtill ſtanding, if there had been very little.

Is it not ſafe to infer from theſe four obſervations, that forty-ſix joints are almoſt the *ne plus ultra* of the growth of the cane in moiſt ſoils? and again, that they are the produce of pretty nearly an equal number of weeks which elapſe after the appearance of the firſt joint? for it is impoſſible to think, that the canes continue growing till the time in which one finds many of them rotten; but if I am in the right it follows, that canes of the firſt production, which live after the twelfth or at moſt after the thirteenth month, live as men do who have paſt the age of forty, every day takes ſomething from their vigour. The ſecond productions are the

---

été pluvieuſe, preſque deſſechées quoique ſur pied, s'il y avoit eu très peu de pluye.

Ne peut on pas conclure de ces quatre obſervations que ces 46 nœuds ſont à peu près le *non plus ultra* de l'accroiſſement des cannes dans les terrein humides, que ces 46 nœuds etoient le travail d'á peu près autant de ſemaines qui s'etoient ecoulées depuis la ſortie du premier nœud, puis qu'on ne peut ſuppoſer que les cannes croiſſent juſqu'au moment ou l'on en trouve beaucoup de pourries, et qu'ainſi l'on peut croire que les cannes de *la première production* qui ſubſiſtent encore après douze ou tout au plus 13 mois ſe ſoutiennent comme font les hommes après avoir atteint l'age de 40 ans, tous les jours avec quelque diminu-

tion

the only ones which are then in their perfection; the third and fourth have not yet reached it.

5thly, In a good ſoil, having a favourable expoſition, well drained and worked for a number of years, I have never ſeen any canes with above thirty-eight or forty joints; nor have I ever ſeen any that had ſo many when the length of the cane has fallen ſhort of four feet and a half, nor this except in pretty good years.

6thly, I have never ſeen the firſt joint of the cane appear in ſuch a ſoil ſooner than the fourth or the middle of the third month.

Nor, ſeventhly, have I ever cut ſuch canes at the fourteen or fifteen months end, but I found ſome that were either rotted or dried, according to the ſeaſon; rotted

---

tion de leur valeur réelle: les *ſecondes productions* ſont les ſeules qui ſubſiſtent alors dans leur perfection; les *troiſiemes et quatriemes* ne l'ont pas encore atteinte.

5e obſervation, Dans un bon terrein bien expoſé, egouté, et travaillant depuis pluſieurs années, je n'ay jamais vu de cannes qui euſſent au dela de 38 à 40 nœuds, ny cette quantité de nœuds dans une longueur moindre de 4 pieds et demi, et ces 4 pieds et demi avec leur 40 nœuds ſeulement dans des années aſſez favorables.

6e obſervation, Je n'ay jamais vu la canne nouée dans cette eſpece de terrein avant le 4e mois ou le milieu du 3e.

7e obſervation, Je n'y ay jamais vu couper les cannes à 14 ou 15 mois ſans en trouver de pourries ou deſſechées ſuivant la ſaiſon, pourries ſi je les coupois après les

ted when I cut them after the January rains; dried when I let them ſtand the three dry months, and cut them in April.

May one not infer from the fifth and ſixth obſervations, that from thirty-eight to forty joints are nearly the *ne plus ultra* of the growth of the cane in a good ſoil, with a favourable expoſition? and that theſe thirty-eight to forty joints are the produce of a like number of weeks which elapſe from the appearance of the firſt joint, at the fourth month's end, or a fortnight ſooner? conſequently, that the only difference between the growth of the canes in ſuch a ſoil, and what it would have been in a moiſt one, is only that the former joint four or five weeks later than the laſt would have done.

And

---

les pluyes en Janvier, deſſechées ſi je les coupois après trois mois de ſec en Avril.

Ne peut-on pas conclure de la 5e et 6e obſervation que les 38 à 40 nœuds ſont à peu près le non plus ultra de l'accroiſſement des cannes dans un bon terrein bien expoſé et egouté, que ces 38 à 40 nœuds ſont le travail de 38 à 40 ſemaines ecoulées depuis la ſortie du premier nœud à 4 mois, ou 3 mois et demi; et qu'ainſi, l'accroiſſement des cannes dans un pareil terrein ne differe de celuy qu'elles prendroient dans un terrein humide que des quatre ou cinq ſemaines qu'elles nouent plutôt dans celuy ci que dans l'autre.

And may not one infer from the fifth, ſixth, and ſeventh obſervations put together, that in a good ſoil, with a favourable expoſition, and well drained, the canes of the firſt production may live the fourteenth month through, perhaps, if they have got to the fourteenth in February, and the dry weather be not exceſſive, reach to the ſixteenth? but that their exiſtence from thirteen months to fifteen will be like that of a ſtout hale man between forty and five and forty, who is much miſtaken if he thinks himſelf as ſtrong then as he was at thirty-five? Whence it follows, that it muſt be advantageous to cut the canes, which grow in ſuch a ſoil, at the twelve month's end, if the other circumſtances of the method which has been adopted allow it; or even at the end of eleven months, if theſe circumſtances require it: becauſe in this laſt caſe one may expect a compenſation

Et ne peut on pas conclure de la 5e, 6e, et 7e obſervations réunies que dans un bon terrein bien expoſé et egouté les cannes de la premiere production peuvent bien ſe ſoutenir juſqu'à 14 mois peutêtre même juſqu'à 15, ſi elles ont atteint le quatorzieme en Fevrier et que le ſec ne ſoit pas bien vif, mais qu'il en ſera de leur etat depuis 13 mois juſqu'à quinze, comme de celuy d'un homme ſec et nerveux depuis 40 juſqu'à 45 ans, qui s'abuſe s'il croit être auſſi vigoureux qu'à 35. D'où il ſuit qu'il ne peut être qu'avantageux de couper dans un pareil terrein les cannes à douze mois ſi les autres circonſtances du ſyſteme qu'on aura adopté peuvent le permettre; et même à 11 mois, ſi les autres circonſtances l'exigent; parce que dans ce cas on peut eſpérer un dedommagement dans la vigueur

tion in the additional vigour given to the ſtump, for the diſadvantages mentioned above by thus cutting before the uſual time.

Obſervation the 8th, In a dry but good ſoil, not manured, but well worked and ſeconded by the ſeaſon, I have never ſeen canes with more than from thirty to thirty-four joints, and theſe on a length of from three to four feet.

Obſervation the 9th, I have never ſeen the firſt joint of theſe come out ſooner than at the end of four months or four months and a half.

Obſervation the 10th, When I have cut theſe at the fifteen months end, I have always found them ſtanding, but very dry, and ſometimes a little changed.

May we not infer from the eighth and ninth obſervations, that from thirty to thirty-four joints is nearly the

ne

vigueur qu'on procure à la ſouche par une coupe anticipée.

8e obſervation, Dans un terrein ſec, quoique bon, point fumé, mais bien travaillé et tres aidé de la ſaiſon, je n'ai jamais vu de cannes qui euſſent au dela de 30 à 34 nœuds, et cette quantité dans une longueur de trois à quatre pieds.

9e obſervation, Je n'y ai jamais vu le premier nœud ſortir avant quatre mois, 4 mois et demi.

10e obſervation, Lorſque j'ai coupé ces cannes à 15 mois, je les ai toujours trouvées ſur pied, mais tres ſeches et quelquefois un peu altérées.

Ne peut-on pas conclure de la 8e et 9e obſervation que ces 30 à 34 nœuds ſont à peu

ne plus ultra of the growth of the canes in a ſoil which is good, though dry; not manured, but pretty well worked, and ſeconded by the ſeaſon?

And may we not infer from the three obſervations put together, that theſe thirty to thirty-four joints are the work of as many weeks which have elapſed ſince the appearance of the firſt joint at the end of four months or four months and a half? conſequently, that the growth of the cane in ſuch a ſoil is nearly equal to what it would be either in a moiſt or in a well-manured ſoil, having a good expoſition, with this difference however, that the moiſter the ſoil is, the quicker the canes joint, and the thicker and longer the joints are: ſtill, however, all the real growth of any conſequence takes place in the ſpace of from eleven to twelve months.

Obſervation

à peu près le non plus ultra de l'accroiſſement des cannes dans un terrein bon, quoique ſec, point fumé, mais aſſez bien travaillé et aidé de la ſaiſon.

Et ne peut-on pas conclure des trois obſervations reünies, que ces 30 ou 34 nœuds ſont l'ouvrage d'autant de ſemaines écoulées depuis la ſortie du premier nœud à quatre mois quatre mois et demi, qu'ainſi l'accroiſſement des cannes dans un pareil terrein, eſt à peu près egal à celuy qu'elles prendroient dans un terrein humide ou dans un autre bien expoſé et egouté, avec cette difference cependant que les cannes nouent d'autant plus vite que le terrein eſt plus humide, et que dans ce cas les nœuds ſont plus gros et plus longs, mais qu'enfin tout l'accroiſſement réel ſe trouve renfermé dans l'eſpace d'environ douze à 13 mois.

Obſervation the 11th, In a ſoil which is drier and more parched, particularly in one where tilling or the ſeaſon have not a little made up for the diſadvantages of the expoſition and the ſoil, I have never ſeen canes with more than from twenty-four to twenty-eight joints; but this number I have ſeen even on canes which were not more than two feet high.

12thly, I have never ſeen the cane joint earlier than the end of the fifth month in this ſort of ſoil.

13th, Whenever, after having attempted to cut theſe canes in January, at fifteen months, I have waited for them till April, in conſequence of not being ſatisfied with their appearance, I have not it is true found one of them rotted, but I have found many dried up.

14th,

11e obſervation, Dans un terrein plus ſec, plus aride, et ſur tout ſi le travail ou la ſaiſon n'ont pas un peu balancé le deſavantage de l'expoſition et du ſol, je n'ai jamais vu de cannes qui euſſent au dela de 24 à 28 nœuds, et j'ai vu cette quantité de nœuds même dans des cannes qui n'avoient que deux pieds de haut.

12e obſervation, Je n'ai jamais vu dans un terrein de cette eſpéce la canne nouée avant cinq mois.

13e obſervation, Lorſqu'ayant voulu couper les cannes en Janvier à 15 mois, et n'ayant pas été ſatisfait de leur etat actuel, je les ai attendües juſqu'en Avril, je n'en ai pas trouvé à la verité une ſeule de pourrie, mais j'en ai trouvé beaucoup d'entierement deſſechées.

14th, When canes planted in the ſame kind of ſoil have been either of twelve or fifteen months growth in March or April, and that, either unwilling or unable to cut them then, I have waited till May or June, I have always found many dead ſtumps, the firſt productions entirely dried up in thoſe which had ſtood out beſt, and the ſecond ſo changed that it has been with great trouble and great attention that I have been able to make ſugar of them.

May not one infer from the eleventh, thirteenth, and fourteenth obſervations, that from twenty-four to twenty-eight joints are the greateſt growth which canes can take in ſuch a ſoil?

And may one not infer from the twelfth obſervation, that theſe joints are the produce of an equal number of weeks,

---

14e obſervation, Dans ce même terrein, lorſque les cannes ont eu dans le mois de Mars et d'Avril ſoit 12 ſoit 15 mois, et que je n'ay pas voulu ou pu les couper alors, j'ai trouvé au mois, de May et de Juin ſuivant, beaucoup de ſouches mortes, j'ai trouvé dans celles qui avoient reſiſté, le plus grand nombre des *premieres* productions totalement deſſechées, et les *ſecondes* ſi alterées par le ſoleil, que ce n'a été qu'avec beaucoup de peine et d'attention qu'on a pu en faire du ſucre.

Ne peut on pas conclure de la 11e, 13e, et 14e obſervation que ces 24 à 28 nœuds des cannes dans cette eſpéce de terrein ſont le non plus ultra de l'accroiſſement qu'elles peuvent y prendre.

Et ne peut on pas conclure de la 12e, que ces 24 à 28 nœuds ſont l'ouvrage

weeks, which being added to the five months or five months and a half, which elapſed before the appearance of the firſt joint, make only twelve or thirteen months of real growth, both for the canes which are planted in a dry ſoil, and for thoſe which are planted in a moiſt one, the difference only, as I obſerved higher, there is between the length and thickneſs of the joints excepted?

15th obſervation, When good care has been taken to manure and work theſe dry places, I have always ſeen the productions of them every way equal to thoſe which had come from a ſoil well expoſed and well drained.

16th obſervation, When heaps of dung have been laid upon particular parts of ſuch a ſoil, in order to diſtribute them thence throughout the remainder of the plantation, I have always ſeen the canes, grown in which had thoſe places which had been covered with the dung, rotted or dried

---

d'autant de ſemaines qui jointes au cinq mois, cinq mois et demi ecoulés avant la ſortie du premier nœud ne ſont que douze à 17 mois d'accroiſſement réel dans les cannes du terrein le plus humide, reſervé comme j'ai dit plus haut la difference de longueur et de groſſeur des nœuds.

15e obſervation, Lorſqu'on a eu ſoin de travailler parfaitement et de bien fumer ces endroits arides, j'y ai toujours vu les productions egales en tout à celles d'un bon terrein bien expoſé et egouté.

16e obſervation, Lorſqu'on a fait des tas de fumier ſur quelques parties de ce terrein ſec et avide pour les diſtribuer dans le reſte de la piéce, j'ai toujours vu les cannes dans ces petits eſpaces qui avoient été couverts de fumier, pourries ou

dried (according to the ſeaſon) at the thirteen months end, as the canes of the moiſt ſoil were. This difference, however, I found between the two ſorts when both were cut at the twelvemonths end; the ſugar which was made of the canes that had grown on the ſoil that was too much dunged burned in April; whereas that made from the canes of the moiſt ſoil was finer then than at any other ſeaſon.

17th, I have ſeen the effects of theſe heaps of dung ten years after. The part which had been covered with it gave excellent productions at that diſtance of time.

May we not conclude from the fifteenth and ſixteenth obſervations, that it is always the fault of the planters, and never that of the plant, if it happens that the cane is not fit to cut at the twelve months end? Now, ſuppoſing

---

ou deſſechées, ſuivant la ſaiſon, à 13 mois, comme les cannes du terrein humide; j'y ai cependant obſervé cette différence qu'en les coupant les unes et les autres à douze mois, le ſucre des cannes du terrein trop fumé bruloit en Avril, et que celuy des cannes du terrein humide, ſe feſoit alors plus beau qu'en aucune autre ſaiſon.

17e obſervation, J'ai vu, même après dix ans, l'effet de ces tas de fumier, et tous les eſpaces ſur leſquels ils avoient été mis donner encore *d'excellentes productions.*

Ne peut-on pas conclure de la 15e et 16e obſervation que c'eſt toujours la faute du cultivateur et jamais celle de la plante ſi la canne n'eſt pas bonne à couper

poſing that the canes planted in October and November are fit to be cut at the end of the twelvemonth, the rains which fall at that time prevent the making any ſugar, unleſs one chuſes to make it execrable, and kill all one's cattle. I ſay nothing of December plantations, becauſe, except in very highly favoured ſoils indeed, it is rare that one plant in ten ſucceeds, the dry weather is too near.

May we not infer from the ſeventeenth obſervation, that it is likewiſe the fault of the planters, and by no means that of the ſoil, if the latter does not afford excellent productions, that is, in other words, good rattoons at the ſixth cutting?

Finally, may we not infer from the hiſtory of the cane in all kinds of ſoils, that if there be any in which it can

---

couper à 12 mois; or en ſuppoſant que les cannes plantées en Octobre et Novembre fuſſent bonnes à couper douze mois après, la pluye qui tombe alors en abondance ne permettroit pas de faire du ſucre à moins qu'on ne voulut le faire abominable et ecraſer les beſtiaux. Je n'ai point parlé ici des plantations de Decembre parce qu'il eſt rare que dans les terreins qui ne ſont pas privilegiés, il en reuſſiſſe deux ou trois ſur dix, le ſec eſt trop voiſin?

Ne peut-on pas conclure de la 17^e^ obſervation que c'eſt auſſi la faute du cultivateur, et point du tout celle du terrein, s'il ne donne pas encore *d'excellentes productions*, c'eſt à dire en d'autres mots, de bons rejettons, à la ſixieme coupe.

Et ne peut-on pas enfin conclure de l'hiſtoire générale de la canne dans toutes les eſpéces de terreins, que s'il en eſt, ou elle peut ſubſiſter juſqu'à 15 et 16 mois,

can exiſt till the fifteenth or ſixteenth month, it never grows to any kind of purpoſe in any after the thirteenth? Perhaps the accuracy with which I have followed it may authorize me to ſay boldly after the twelfth.

Hiſtory of a ſingular revolution in the inſide of the cane, and of the arrow which comes out in conſequence of that revolution, and conſtitutes the laſt ſtage of the plant's exiſtence.

A principal and neceſſary effect of the dry weather on the cane is, the diminution of the watery parts of its juice. There is no reaſon, therefore, for being ſurprized, either that the ſame quantity of canes which affords from 140 to 160 gallons of it in January ſhould only afford 90 to 100 in April, or that there ſhould be as much

---

mois, elle ne croît cependant jamais d'une façon utile au dela de 13? peut être même dirai-je affirmativement douze, après l'avoir ſuivie juſques dans ſon dernier developpement.

Hiſtoire d'une revolution ſinguliere dans l'interieur de la plante; de la fleche qui la ſuit, et qui forme le dernier developpement de la canne.

L'effet principal et neceſſaire du ſec ſur la canne, eſt la diminution de la partie aqueuſe de ſon jus; l'on ne ſera donc point ſurpris que la même quantité de cannes qui en donne au mois de Janvier 140 à 160 gallons, n'en donne que 90 à 100

much ſugar made from the latter as from the former. This follows of courſe; but it ſhould ſeem, that upon the return of the rains, the cane ſhould recover the water, which the heats of February, March, and April, had made it loſe: the reverſe, however, is what in fact happens; not only the quantity of the juice is leſs, but the quality of it is worſe; it contains leſs ſugar in it, and when the weather is fairly ſettled, when the rains are frequent and abundant, which generally happens from the firſt of July to the 13th of Auguſt, the whole vegetative faculties of the plant ſeem employed in the production of the arrow, ſee *oop*, fig. 1. During that time the body of the cane is almoſt totally deſtitute of juice, which is carried in great plenty towards the head of it. Soon after there comes out from the top of the arrow, a thin

---

à 100 dans le mois d'Avril, n'y que ces 90 gallons d'Avril donnent autant de ſucre que les 160 de Janvier: mais il ſembleroit qu'au retour des pluyes, la canne devroit recouvrer l'eau qu'elle a perdue par le ſoleil conſtant de Fevrier, Mars, et Avril; c'eſt le contraire qui arrive; non ſeulement le jus diminüe, mais ſa qualité ſe deteriore, il contient moins de ſucre, et lorſque le renouveau eſt tout à fait decidé, que les pluyes ſont frequentes et abondantes, ce qui arrive ordinairement du 1 Juillet au 15 d'Aouſt, il ſemble que tous les efforts de la vegetation ſoient conſacrés à la production de la fleche, v. *oop*, fig. 1. Le corps de la canne eſt alors preſque totalement deſtitué de ſon jus qui ſe porte en abondance vers la tête de la plante; bientôt il ſort de ſon extremité une tige

thin pointed ſtem, which grows about three feet high in the ſpace of five or ſix weeks, then blows at the end, and is crowned with a panicle like that of a reed. *oop*, fig. 1. ſhews the arrow crowned with its panicle; it is commonly full-blown towards the end of October, withers ſoon after, and falls in the following month. Some people pretend, that this panicle contains the ſeed of the cane; I have ſown the kind of ſeed or duſt which comes from it, and nothing has come up. Perhaps the cane which is propagated by ſhoots bears only empty huſks. Be this as it may, when once the arrow has appeared, the cane is in its laſt ſtage.

After the fall of the leaf, which takes place a little ſooner or a little later, according to the ſeaſon, the joints which preceded it dry up, in their order. This mortification,

---

aſſez grêle et pointue qui s'eleve dans l'eſpace de cinq à ſix ſemaines juſqu'à la hauteur d'environ trois pieds, ſe developpe enfin par ſa pointe et ſe couronne d'un panache ſemblable à celuy du roſeau. *oop*, fig. 1. preſente la fleche couronnée de ſon panache; elle eſt ordinairement tout à fait developpée à la fin d'Octobre, peu après elle ſe deſſeche, elle tombe le mois ſuivant. Quelques perſonnes pretendent que ce panache contient la ſemence de la canne, je n'en ſçais rien, mais j'ai ſemé l'eſpece de pouſſiere ou de graine qui en ſort, et rien n'a levé, peut-être que la canne qui vient de bouture ne porte que des graines folles. Quoiqu'il en ſoit, après que la fleche eſt ſortie, la canne eſt à ſon dernier periode; et un peu plus tôt, un peu plus tard, après la chute de la feuille (toujours ſuivant la ſaiſon) les nœuds qui la precedent ſe deſſechent ſucceſſivement, et cette

tification, if I may ſo call it, never ſtops, except when there happens to come out a kind of ſpurious top about the eighth or ninth joint from the arrow, ſee *l*, *m*, fig. 1.

It comes out of two joints which blow after the fall of the arrow, when there happens to be much rain. This ſpurious head ſerves much the ſame purpoſes as the true one; for it aſſiſts, maintains, and preſerves the action of the ſap in that part of the cane which ſtill remains alive, ſo that whenever there is not rain enough to produce it, the laſt joints die off like the former.

It is farther to be obſerved with regard to the arrow, 1ſt, that this any more than the ripeneſs does not depend upon the age of the cane, but upon the ſeaſon. In October and November the canes of ſix months growth bear arrows like thoſe of twelve or fifteen months, but all canes do not bear arrows.

2d, Though

---

cette gangrene, ſi j'oſe m'expliquer ainſi, n'eſt arrêtée que lorſqu'il ſe forme une eſpéce de fauſſe tête vers le 8e et 9e avant dernier nœud, v. *l*, *m*, fig. 1.

Ce ſont deux nœuds qui ſe developpent après la chute de la fleche, s'il y a beaucoup de pluye, et qui forment cette fauſſe tête qui fait en partie l'office de la premiere, puis qu'elle entretient l'action de la ſeve dans la partie de la canne qui reſte encore ſaine, et que s'il ne fait pas aſſez de pluye pour que ces deux nœuds ſe developpent, tous ſe deſſechent ſucceſſivement juſqu'à la racine.

Obſervons encore par rapport à la fléche, 1°, qu'ainſi que la maturité, elle n'eſt point l'effet de l'age de la canne, mais de la ſaiſon; dans le mois de Septembre ou d'Octobre les cannes de ſix mois *flechent* comme celles de 12 et de 15; mais toutes les cannes ne ſont pas ſuſceptibles de ce phenomene.

2d, Though ſome canes have no arrow, they are all ſubject to that internal revolution of which I have ſpoken, *viz.* the diminution and impoveriſhment of their juices.

3d, Whenever in a plantation, the ſoil of which, though good, had been accidentally abandoned, there has happened to be found a ſhrub ſtrong enough to ſerve as a prop to a cane having an arrow and ſhoots from its eighth or ninth joint (*l*, *m*, fig. 1.); theſe ſhoots have each of them produced a cane: far inferior indeed in beauty to that out of which they had themſelves ſprung, but which, doubtleſs, would have wanted nothing to have born an arrow and canes in their ſeaſon alſo, but ſuch another ſhrub as that to which they owed their exiſtence.

I know nothing of the obſervations upon which the opinion is grounded, that the cane does not come to perfection

---

2°, Que les cannes qui ne flechent pas n'en éprouvent pas moins la revolution interieure dont j'ay parlé, cette diminution et appauvriſſement de leur jus.

3°, Que lorſqu'il s'eſt trouvé dans une piéce de cannes abandonnée (bonne terre cependant) quelque arbriſſeau qui a pu ſervir d'appuy à une canne flechée et aux jets ſortis de ſon 8e et 9e nœud (*l*, *m*, fig. 1.). Ces jets ont donné chacun une canne beaucoup moins belle à la verité que celle dont ils ſortoient, mais qui n'auroit ſans doute eu beſoin pour flecher dans ſon tems, et donner enſuite d'autres petites cannes, que d'être appuyée comme celle qui l'avoit produite.

J'ignore les obſervations d'après leſquelles on peut prétendre que la canne a

fection under fourteen or fifteen months. Thoſe of which I have been giving an account ſeem very poſitively to eſtabliſh that, *conſidered with regard to its greateſt uſefulneſs, the cane is an annual plant producing by the root*; conſequently, the mode of cultivation which agrees beſt with it, that which will anſwer beſt to the planter, will be that which, conſidering theſe as the two capital points to be attended to, connects them the beſt with the neceſſary influence the ſeaſons of the climate in which the cane grows will have upon it. Now I truſt that in theſe two reſpects my method will ſtand the teſt of examination.

It remains to ſpeak of the hiſtory of the cane according to the two methods.

Hiſtory

---

beſoin de 14 à 15 mois pour être dans ſa perfection: celles que je viens de preſenter me paroiſſent établir d'une façon bien poſitive que *relativement à ſon plus grand degré d'utilité la canne eſt une plante annuelle, et vivace par ſa racine*, qu'ainſi le ſyſteme de culture qui lui convient, le ſyſteme le plus avantageux au cultivateur ſera celuy qui aura ces deux points pour baſe, et qui les combinera le mieux avec les effets que doivent operer ſur elle, les différentes ſaiſons qui regnent dans les climats où on la cultive, et j'oſe croire que mon ſyſteme, peut ſoutenir l'examen à ces deux égards.

Il me reſte à parler de l'hiſtoire de la canne dans les deux ſyſtemes.

Hiſtoire

Hiſtory of the cane according to the two different methods of cultivation, and in different years, the favourable, the dry, and the rainy.

The hiſtory of the cane, according to both methods, flows ſo naturally from what I have ſaid above, as well of the ſeaſons as of their influence on the different productions, firſt, ſecond, and third, that the bare recollection of the time and conditions of their appearance and developement will be ſufficient to lead us to conclude,

1ſt, That in favorable ſeaſons, the *firſt* productions of canes planted in October and November, and cut fifteen months after, have a greater number of joints than thoſe of canes planted in May, and cut the year after at the end of

---

Hiſtoire de la canne dans les deux ſyſtemes, et dans les différentes eſpèces d'années, favorables, ſeches et pluvieuſes.

L'hiſtoire de la canne dans les deux ſyſtemes decoule ſi neceſſairement de ce que j'ai dit cy deſſus tant à l'egard des ſaiſons, que de leur influence ſur les différentes productions *premieres*, *ſecondes*, et *troiſiemes*, qu'il ſuffit de ſe rappeller le tems et les conditions de leur ſortie et de leurs developpements, pour conclure:

1°, Que dans les années favorables, les *premieres* productions des cannes plantées en Octobre et Novembre, coupées quinze mois après ont plus de nœuds que les *premieres* productions des cannes plantées en May, et coupées l'année d'après

of twelve months; but that this exceſs is only equivalent to the vegetation of one month, on account of the dry weather, which neceſſarily impedes it during the months of March and April. As to the *ſecond* productions, they are equal in the two methods, thoſe upon the larger ſcale of cultivation appearing in June to be cut in February, and thoſe of the ſmaller appearing at the end of Auguſt to be cut in May.

2d, The loſs in years of drought muſt be a little more conſiderable on the ſmall plan than on the other; becauſe there being no *ſecond* productions (of real value) in that caſe according to either of the plans, and the difference of the thirteenth month, with regard to the *firſt*, remaining entire, one on thirteen muſt of courſe be more felt than one on a greater number.

3d, In

---

d'après à 12 mois, mais que ce plus n'equivaut qu'à un mois de vegetation, attendu l'effet du ſec qui dans une terre decouverte, la ſuſpend viſiblement pendant les mois de Mars et d'Avril; et que les *ſecondes* productions ſont egales dans les deux ſyſtemes; les *ſecondes* productions de la grande culture ne paroiſſant qu'en Juin pour être coupées en Fevrier, et les *ſecondes* productions de la petite culture paroiſſant à la fin d'Aouſt pour être coupées en May.

2°, Que dans les années ſeches, la perte doit être un peu plus ſenſible dans le ſyſteme de la petite culture, parce que dans l'un n'y dans l'autre ſyſteme on ne verra paroître de ſecondes productions (d'une valeur réelle) et que la difference du treizieme mois ſur les *premieres* demeurant en ſon entier, un eſt plus ſenſible ſur treize que ſur un nombre plus conſiderable.

3°, Que

3d, In rainy years the *ſecond* and *third* productions will be the ſame, according to both the methods, on account of the reaſon given above; to wit, the equality of the time which elapſes between their firſt appearance and the time of their being cut; and becauſe the advantage which the great method might expect from its *firſt* productions will be loſt by their being rotten at the time of cutting.

Finally, that the total difference in the produce of a number of years taken together, cannot be conſiderable enough not to be much more than made up for by the produce of my ſecond crop, or rather by cutting the whole land, inſtead of cutting only three parts of it.

Notwithſtanding the ſtrong reaſons I have to determine me to the choice of the ſmall plan, I confeſs the force

---

3°, Que dans les années pluvieuſes, les *ſecondes* et *troiſiemes* productions ſeront egales dans les deux ſyſtemes par la raiſon que nous avons donnée cy deſſus de l'egalité du tems qui s'ecoule entre la ſortie et la coupe des unes comme des autres, et que le benefice que le ſyſteme de la grande culture pourroit eſpérer de ſes *premieres* productions ſe trouvera en pourriture au tems de la coupe.

4°, Enfin que la différence totale ſur le produit des années combinées ne peut être aſſez conſiderable pour n'être pas beaucoup plus que compenſée par le produit de ma ſeconde recolte, ou plutôt par une recolte ſur toute la terre au lieu d'une recolte ſur les trois quarts.

Malgré l'evidence des raiſons qui devoient me decider à ſuivre le ſyſteme de la petite culture j'avoue que la force du vieux prejugé m'a tenu moy même très long

force of old prejudices long held me in ſuſpence. I think, however, I may with confidence propoſe it, as I have the experience of five years to bear me up in aſſerting that, one year with another, there is a difference of above one fifth in its favour.

EXPLA-

long tems en ſuſpens, mais je crois devoir le propoſer lorſque je puis prouver par une expérience de cinq années conſecutives une différence de quelque choſe de plus qu'un ſixieme en ſa faveur, une année priſe dans l'autre.

EXPLANATION OF THE FIGURES.

Figure the firſt ſhews a cane entirely without leaves.

N° 1. Is the firſt order of roots; they come out of the joint to which the bud which is to produce the cane is faſtened. All they ſtand in need of to make them come out is the moiſture which is contained in the medullar part of the plant, and the little fermentation which ariſes from the want of circulation after the two extremities *y* and *z* have been cut.

N° 2. Shews the ſecond order of roots, compoſed of its firſt ſet *aa*, of its ſecond *bb*, of its third *cc*, of its fourth *dd*. Theſe four ſets of the ſecond order come out

---

La figure entiere repreſente une canne à ſucre dépouillée entierement de ſes feuilles.

N° 1. Preſente le premier ordre de racines, elles ſortent du nœud auquel eſt attaché le bouton qui doit produire la canne. Elles n'ont beſoin pour ſortir que de l'humidité contenue dans la partie médullaire du plan et de la petite fermentation qui ſuit le défaut de circulation ou de balancement de la ſéve après que les deux extrémités y et z ont été coupées.

N° 2. Preſente le ſecond ordre de racines compoſé de ſon premier plan *aa*, du ſecond *bb*, du troiſieme *cc*, du quatrieme *dd*; ces quatre plans du ſecond

out of the quadruple ſheath *abcd*, which contained the bud. The firſt ſet of theſe roots cannot come out without puſhing away the leaf which wraps up the whole, no more can any of the reſt; I believe the part marked *r* is the neck of the plant, or the place at which it comes out of the ground.

N° 3. Shews the third order of roots, compoſed of its firſt ſet *ee*, of its ſecond *ff*, of its third *gg*, and of its fourth *bb*. Each of theſe ſets as it comes out likewiſe throws down one of thoſe leaves, which in the body of the work I have called the external, or *proper* leaves of the plant. What is meant to be ſhewn here is rather the place than the length of them, as they are commonly between twenty and thirty inches long. *x* and *x* are the ſecond productions or immediate growths of the ſtump.

Theſe

---

ordre proviennent du quadruple étui de feuilles ſeminales *abcd*, qui enveloppoient l'embryon. Le premier plan de ces racines n'a pu ſortir ſans chaſſer la feuille enveloppe du tout; ainſi des autres. Je crois que la partie *r* forme le collet de la plante.

N° 3. Preſente le troiſieme ordre de cannes compoſé de ſon premier plan *ee*, du ſecond *ff*, du troiſieme *gg*, du quatrieme *bb*: chacun de ces plans fait ainſi tomber en ſortant une de ces feuilles que j'appelle dans l'extrait, extérieures ou propres de la plante: je déſigne ici plutôt leur place que leur longueur puiſqu'elles ont ordinairement depuis vingt juſqu'à trente pouces. *x* et *x* ſont les

Theſe ſecond productions come from buds which adhere to ſets of roots of the third order, which third order is the only one which gives productions out of the earth. The third productions, *t*, *t*, come out of the ſecond. The number of the ſets of roots of the third order is unlimited. The ſecond is confined to four ſets. The part between *i* and *k* ſhews the effects of a very dry ſeaſon; the joints are ſtunted, and ſometimes only two lines long, inſtead of an inch and a half or two inches. When the rains begin again, the joints which come out are again larger; ſee from *k* to *l*, where they are as big as they were between *b* and *i*.

The part from *l* to *n* is what is made uſe of for planting; *yz* is the plant without its leaves. It is, however, commonly put into the ground with its leaves, as in

---

ſecondes productions propres de la ſouche, ces ſecondes productions ſortent des boutons attachés aux plans de racine du troiſieme ordre qui ſeul donne des productions hors de terre. Les troiſiemes productions *t* et *t* ſortent des ſecondes. Le nombre des plans de racine du troiſieme ordre eſt illimité; le ſecond ordre eſt borné à quatre plans. Depuis *i* juſques à *k* on voit l'effet d'un ſec très vif, les nœuds ſont étranglés et n'ont quelquefois que deux lignes au lieu d'un pouce et demi deux pouces. Lorſque les pluies recommencent les nœuds qui ſortent ſont plus longs, comme on les voit depuis *k* juſqu'à *l*, tels qu'ils étoient depuis *b* juſqu'à *i*.

La partie depuis *l* juſqu'à *n* eſt celle qui ſert de plan; *yz* eſt le plan dépouillé de ſes feuilles, on le met cependant en terre avec ſes feuilles tel qu'il

In figure 7th. *u* is the ligament by which the bud is faſtened to the plant. *oo* is the laſt production of the plant, and is called the arrow; it appears at firſt as an arrow (*oo*), and is then crowned with a pannicle *p*; it ſhoots in September or October, and falls in November or December. It is ſaid, that this pannicle contains the ſeed of the plant.

I have ſown it, but nothing has come up. When the arrow has dried, and is fallen off, the joints below it dry one after the other, when there is little or no rain; but if there happens to be much rain, the eighth and ninth, or tenth and eleventh joints from the top (ſee from *l* to *m*) unfold, and form a ſecond head, which keeps up the vegetation in the lower part of the plant ſome time longer. If theſe joints were to be ſupported as

---

qu'il eſt dans la figure 7. *u* eſt l'ombilic par lequel l'embryon eſt attaché au plan. *oo* eſt la derniere production de la canne: on l'appelle la fleche: elle paroit d'abord comme une fleche telle qu'elle eſt en *oo* et ſe couronne enſuite d'une panache *p*, elle ſort en Septembre ou Octobre, et tombe en Novembre ou Decembre. On pretend que ce panache contient la graine de la plante.

J'ai ſemé cette prétendue graine, rien à levé. Après que la fleche eſt ſéchee et tombée, les nœuds qui la précedent ſe deſſechent ſucceſſivement, s'il ne pleut que très peu, ou bien les huitieme et neuvieme, ou dixieme et onzieme avant dernier nœud *lm* ſe développent et forment une ſeconde tête qui entretient encore la vegetation dans le reſte de la plante. Ces nœuds appuyés à meſure qu'ils ſe

as they come out, they would produce canes, but of an inferior sort to the others. All canes have not arrows, and the coming out of an arrow depends on the season, and not on the age of the cane.

---

se développent donneroient des cannes aussi mais beaucoup moins belles que les autres ; toutes les cannes ne flechent point ; et c'est la saison et non pas l'age de la canne qui décide la sortie de la fleche.

Fig.1
Fig.2
Fig.3
Fig.4
Fig.5
Fig.7
Fig.8
Fig.9
Fig.10

XX. *Account of the* Free Martin.

By Mr. John Hunter, *F. R. S.*

Read February 25, 1779.

GENERATION, when produced from a ſeed, has two cauſes which concur towards its perfection; the one which forms the ſeed, the other which gives it the principle of action [a].

The cauſe which forms the ſeed is called the female, the other cauſe is called the male; but thoſe two cauſes in general make only a part of a whole animal, or are

(a) It may be neceſſary for ſome of my readers to have explained to them what I mean by a ſeed. I do ſuppoſe, that the word ſeed was firſt applied to grain, or that which is always called ſeed in the vegetable; which ſeed is the part of that claſs of vegetables in which the matter of the young vegetable exiſts, or is formed. The principle of arrangement fitting the parts for action in this claſs of ſeed being at firſt not known, a falſe analogy between the vegetable and animal was eſtabliſhed, *viz.* the ſecretion of the *teſtes* (the only known principle in the animal) was called the ſeed: but from the knowledge of the diſtinct ſexes in the vegetable it is well known, that the ſeed is the female production in them, and that the principle of arrangement for action is from the male. The ſame operation and principles take place in many orders of animals, *viz.* the female produces a ſeed, in which is the matter fitted for the firſt arrangement of the organs of the animal, and which receives the principle of arrangement fitting them for action from the male.

rather

rather parts ſuperadded to an animal. Probably they were firſt conſidered in thoſe animals where thoſe parts were ſeparated, or in which the female parts were wholly found in one animal and the male in the other; therefore the terms female and male have been applied to the whole animal, dividing them into two diſtinct ſexes, and the parts which formed either the one ſex or the other called either the female or the male parts of generation; but upon a further knowledge of animals, and of thoſe parts, they were found to be united in the ſame animal in many of the inferior tribes, who, from poſſeſſing both parts, have got the name of hermaphrodite.

As both thoſe parts are natural to moſt animals, and as the union of them in the ſame animal is alſo natural to many, and the ſeparation of them in diſtinct animals, is only a circumſtance making no eſſential difference in the parts themſelves; it becomes no great effort or uncommon play in nature to unite them in thoſe animals in which they are commonly ſeparated.

And accordingly we find many of thoſe orders of animals, which have them ſeparate naturally, have them ſometimes united.

From this account hermaphrodites may be divided into two kinds; the natural, and the unnatural uncommon or monſtrous.

The natural belongs to the inferior and more ſimple order of animals, of which there are a much greater number than of the more perfect; but as animals become more complicated, have more parts, and each part is more confined to its particular uſe, a ſeparation of the two neceſſary powers for generation have alſo taken place in them.

The unnatural, I believe, now and then takes place in every tribe of animals having diſtinct ſexes, but is more common in ſome than in others (*b*). I fancy the human has the feweſt, never having ſeen them in that ſpecies nor in dogs: cats we know leſs of; but in the horſe, aſs, ſheep, and cattle, they are very frequent.

Though this ſpecies of hermaphrodite be a mixture of both ſexes, and ſo poſſeſſes the parts peculiar to each in perfection, there is yet one part of each which it does not poſſeſs: I mean the part which is common to both. For as this common part is different in one ſex from what it is in the other, and it is impoſſible for one animal to have both kinds; that which they do have muſt of courſe partake of both ſexes, and conſequently render the hermaphrodite imperfect *quoad hoc*.

(*b*) *Quæ*, Is there ever in the tribe of animals, that are natural hermaphrodites, a ſeparation of the two parts?

This one or common part is the *clytoris* in the female, and *penis* in the male; and the great difference in this part between the one ſex and the other is ſize and perforation for the *ſemen*.

But thoſe parts, which are peculiar to each ſex, may be all perfectly joined in the ſame animal, which would come up to the idea of the trueſt hermaphrodite.

The hermaphrodites of this kind, which I have ſeen, have always appeared externally, and, at firſt view, to be females: and in thoſe ſpecies of animals where only the female is preſerved for breeding, as in ſheep, goats, pigs, &c. they are generally ſaved as females.

In the horſe they are very frequent: I have ſeen ſeveral, but never diſſected any. The moſt perfect I have ſeen in this ſpecies were thoſe in which the teſticles had come down out of the *abdomen* into the place where the udder ſhould have been (*viz.* more forward than the *ſcrotum*) and appeared like an udder, not ſo pendulous as what the *ſcrotum* is in the true male of ſuch animals. There were alſo two nipples, which horſes have no perfect form of, being blended in them with the ſheath or *prepuce*, of which there was none here.

The external female parts were exactly ſimilar to thoſe of the perfect female; and, inſtead of a common-

ſized

ſized *clytoris*, there was one about five or ſix inches long, which, when erect, ſtood almoſt directly backwards.

I procured a foal aſs, very ſimilar in external appearance to the above horſe, and killed it, to examine the parts. It had two nipples, but the teſticles were not come down as in the above; owing, perhaps, to the animal's being yet too young.

There was no *penis* paſſing round the *pubis* to the belly as in the perfect male aſs.

The external female parts were ſimilar to thoſe of the ſhe-aſs. Within the entrance of the *vagina* was placed the *clytoris*, but much longer than that of a true female, being about five inches long. The *vagina* was open a little further than the opening of the *urethra* into it, and then became obliterated; from thence up to the *fundus* of the *uterus* there was no canal.

At the *fundus* of the common *uterus* it was hollow, or had a cavity in it, and then divided into two, *viz.* a right and a left, called the horns of the *uterus*, which were alſo pervious.

Beyond the termination of the two horns were placed the *ovaria* as in the true female, but I could not find the *fallopian* tubes.

From the broad ligaments to the edges of which the horns of the *uterus* and the *ovaria* were attached, there

paſſed towards each groin a part ſimilar to the round ligaments in the female, which were continued into the rings of the *abdominal* muſcles; but with this difference, that there were continued with them a *proceſs* or *theca* of the *peritoneum*, ſimilar to the *tunica vaginalis communis* in the male aſs, and in theſe *thecæ* were found the teſticles: but I could not obſerve any *vaſa deferentia* paſſing from them.

Here then we found in the ſame animal the parts peculiar to each ſex (although very imperfect), and that part which is common to both (but different in each) was a kind of medium of that difference.

Something ſimilar to the above I have ſeen in ſheep, goats, &c.; but I ſhall not at preſent trouble the Society with a deſcription of hermaphrodites in general, as it is a very extenſive ſubject, admitting of great variety, which would make it appear a production of chance, whereas the intention of this paper is to ſhow a circumſtance which takes place in the production of hermaphrodites in cattle, and which appearing to be an eſtabliſhed principle in the œconomy of propagation of that ſpecies of animal, and not a production of chance, is, perhaps, peculiar to them, and, probably, the only way in which they are ever produced in this ſpecies.

It is a known fact, and, I believe, is understood to be universal, that when a cow brings forth two calves, and that one of them is a bull-calf, and the other a cow to appearance, the cow-calf is unfit for propagation; but the bull-calf becomes a very proper bull. They are known not to breed: they do not even shew the least inclination for the bull, nor does the bull ever take the least notice of them [c].

This cow-calf is called in this country a *free martin*; and this singularity is just as well known among the farmers as either cow or bull.

This calf has all the external marks of a cow-calf similar to what was mentioned in the unnatural hermaphrodite, *viz.* the teats and the external female parts, called by farmers the bearing.

When they are preserved it is not for propagation, but for all the purposes of an ox or spayed heifer, *viz.* to yoke with the oxen, and to fatten for the table [d].

They resemble in form those imperfect animals very much, *viz.* they are much larger than either the bull or the cow, and the horns grow larger, being very similar to the horns of an ox.

(c) I need hardly observe here, that if a cow has twins, and that they are both bull-calves, that they are in every respect perfect bulls; or if they are both cow-calves, that they are perfect cows.

(d) *Vide* LESLIE on Husbandry, p. 98, 99.

The

The bellow of the free martin is ſimilar to that of an ox, which is not at all like that of a bull; it is more of the cow, although not exactly that.

The meat is alſo ſimilar to that of the ox or ſpayed heifer, *viz.* much finer in the fibre than either the bull or cow; and they are more ſuſceptible of growing fat with good food. By ſome they are ſuppoſed to exceed the ox and heifer in delicacy of food, and bear a higher price at market.

However, it ſeems that this is not univerſal; for I was lately informed by CHARLES PALMER, eſq. of Luckley in Berkſhire, that there was a free martin killed in his neighbourhood, and, from the general idea of its being better meat than common, every neighbour beſpoke a piece, which turned out nearly as bad as bull beef, at leaſt worſe than that of a cow. It is probable, that this might ariſe from this one having more the properties of the bull than the cow, as we ſhall ſee hereafter that they are ſometimes more the one than the other (*t*).

Free

(*t*) The Romans called the bull *taurus*: they, however, talked of *taura* in the feminine gender. And STEPHENS obſerves, that it was thought the Romans meant by *taura*, barren cows, and called them by this name becauſe they did not conceive any more than bulls. He alſo quotes a paſſage from COLUMELLA, lib. vi. cap. 22. "and like the *taura*, which occupy the place of

Free martins are ſaid to be in ſheep (*f*); but from the accounts given of them, I ſhould very much ſuſpect that theſe are hermaphrodites produced in the common way, and not like thoſe of cattle. They are often imperfect males, ſeveral of which I have ſeen. They are mentioned as both male and female, which is not reconcileable to the account given of the free martin.

I believe it has never been even ſuppoſed what this animal is, with all thoſe peculiarities.

From the ſingularity of the animal, and the account of its production, I was almoſt ready to ſuppoſe the account a vulgar error; yet from the univerſality of its teſtimony it appeared to have ſome foundation; and therefore I made all the inquiry I could for an opportunity of ſeeing one, and alſo to examine it. Since which time I have accordingly had an opportunity of ſeeing three; the firſt of which was one belonging to JOHN ARBUTHNOT, eſq. of Mitcham, which was calved in his own farm. He was ſo obliging as to give me an opportunity of ſatisfying myſelf. He allowed me, firſt, to have a drawing made of the animal while alive, which was exe-

" fertile cows, ſhould be rejected, or ſent away." He likewiſe quotes VARRO, *De re Ruſtica*, lib. ii. cap. 5. " The cow which is barren, is called *taura*." From which we may reaſonably conjecture, that the Romans had not the idea of the circumſtances of their production.

(*f*) LESLIE's Huſbandry, p. 156.

cuted

cuted by Mr. GILPIN. When the drawing was made of Mr. ARBUTHNOT's free martin, JOHN WELLS, eſq. of Bickley Farm, near Bromley in Kent, was preſent, and informed us, that a cow of his had calved two calves; and that one was a bull-calf, and the other a cow-calf. I deſired Mr. ARBUTHNOT to ſpeak to Mr. WELLS to keep them, or let me buy them of him; but, from his great deſire for natural knowledge, he very readily preſerved both, till the bull ſhewed all the ſigns of a good bull, when he ſold him.

From the diſſection of the three above mentioned free martins it plainly appeared, that they were all hermaphrodites differing from one another; as is alſo the caſe in hermaphrodites in other tribes.

The

The Deſcription of the three Free Martins.

Mr. ARBUTHNOT's Free Martin [g].

The external parts were rather ſmaller than in the cow. The *vagina* paſſed on, as in the cow, to the opening of the *urethra*, and then it began to contract into a ſmall canal, which paſſed on to the diviſion of the *uterus* into the two horns, each horn paſſed along the edge of the broad ligament laterally towards the *ovaria*.

At the termination of thoſe horns were placed both the *ovaria* and the teſticles; both were nearly of the ſame ſize, which was about as large as a ſmall nutmeg.

To the *ovaria* I could not find any *Fallopian* tube.

To the teſticles were *vaſa deferentia*, but they were imperfect. The left one did not come near the teſticle; the right only came cloſe to it, but did not terminate in a body called the *epididymis*. They were both pervious, and opened into the *vagina* near the opening of the *urethra*.

(g) This animal was about ſeven years old, had been often yoked with the oxen; at other times went with the cows and bull, but never ſhewed any deſires for either the one or the other.

On the posterior surface of the bladder, or between the *uterus* and bladder, were the two bags, called *vesiculæ seminales* in the male, but much smaller than what they are in the bull: the ducts opened along with the *vasa deferentia*. This was more deserving the name of hermaphrodite than the two following; for it had a mixture of all the parts, although all were imperfect.

Mr. WRIGHT's Free Martin, *five years old.*

The *vagina* terminated in a blind end, a little way beyond the opening of the *urethra*, beyond which the *vagina* and *uterus* were impervious. The *uterus* at its extreme part divided into two horns. At the termination of the horns were placed the testicles instead of the *ovaria*, as is the case in the female. The reasons why I call those bodies testicles are the following. First, they were more than twenty times larger than the *ovaria* of the cow, and nearly as large as the testicles of the bull, particularly as those of the ridgill, the bull whose testicles never come down. Secondly the spermatic arteries were exactly similar to those of the bull, especially of the ridgill. Thirdly, the *cremaster* muscle passed up from the

the rings of the abdominal muſcles to the teſticles, as it does in the ridgill [b].

There were the two bags placed behind the bladder, between it and the *uterus*. Their ducts opened into the *vagina*, a very little way beyond the opening of the *urethra*; but there was nothing ſimilar to the *vaſa deferentia*.

As the external parts had more of the cow than the bull, the *clytoris*, which may alſo be reckoned an external part, was alſo ſimilar to that of the cow; not at all in a middle ſtate between the *penis* of the bull and the *clytoris* of the cow, as I have deſcribed in the hermaphrodite horſe. There were four teats; the glandular part of the udder was but ſmall.

This animal cannot be ſaid to have been a mixture of all the parts of both ſexes, for the *clytoris* had nothing ſimilar to the *penis* in the male, and was different in the cow part, in having nothing ſimilar to the *ovaria*, nor was the *uterus* a cavity.

[b] Although I call theſe bodies teſticles for the reaſon given, yet they were only imitations of ſuch, for when cut into they had nothing of the ſtructure of the teſticle: not being ſimilar to any thing in nature, they had more the appearance of diſeaſe. From the ſeeming imperfection of the animal itſelf, it was not to be ſuppoſed that they ſhould be teſticles, for then the animal ſhould have partook of the bull, which it certainly did not.

Mr. WELLS's Free Martin.

This animal was never ſeen to ſhew any ſigns of a deſire for the male, although it went conſtantly with one. It looked more like an heifer than what they commonly do; but as it was only between three and four years old when killed, it is very probable, that it was not ſufficiently old to have taken the characters of the ox; however, this may be owing to another circumſtance that will be mentioned hereafter.

The teats and udder were ſmall compared with thoſe of a heifer, but rather larger than in either of the former; the beginning of the *vagina* ſimilar to that of the cow, but it ſoon became obliterated beyond the opening of the *urethra*, as in the laſt deſcribed. The *vagina* and *uterus* to external appearance was continued, although not pervious, and the uterine part divided into two horns, at the end of which were the *ovaria*.

I could not obſerve in this any other body which I might have ſuppoſed to be the teſticle.

There was on the ſide of the *uterus* an interrupted *vas deferens* broken off in ſeveral places.

Behind the bladder, or between it and the *vagina*, were the bags called *veſiculæ ſeminales*, between which were the terminations of the two *vaſa deferentia*.

The ducts of the bags and the *vaſa deferentia* opened as in the former.

This could not be called an exact mixture of all the parts of both ſexes, for here was no appearance of teſticles.

The female parts were imperfect, and there was the addition of part of the *vaſa deferentia*, and the bags called *veſiculæ ſeminales*.

This circumſtance of having no teſticles, perhaps, was the reaſon why it had more the external appearance of a heifer than what they commonly have, and more than either of the two former had.

Behind the bladder, or between it and the vagina, were the bags called vesiculæ seminales, between which were the terminations of the two vasa deferentia.

The ducts of the bags and the vasa deferentia opened as in the former.

This could not be called an exact mixture of all the parts of both sexes, for here was no appearance of testicles.

The female parts were imperfect, and there was the addition of part of the vasa deferentia, and the bags called vesiculæ seminales.

This circumstance of having no testicles, perhaps, was the reason why it had more the external appearance of a heifer than what they commonly have, and more than either of the two former had.

METEOROLOGICAL JOURNAL

KEPT AT THE HOUSE OF

THE ROYAL SOCIETY,

BY ORDER OF THE

PRESIDENT AND COUNCIL.

METEOROLOGICAL JOURNAL

for January 1778.

		Time. H.	M.	Therm. without	Therm. within.	Barom. Inches.	Rain. Inch.	Winds. Points.	Str.	Weather.
Jan.	1	8	0	34,0	35,0	29,69		N	1	Cloudy.
		2	0	35,0	35,0	29,92		N	1	Cloudy.
	2	8	0	32,5	34,5	29,95		N by W	1	Cloudy.
		2	0	36,0	35,5	29,94		NW	1	Fair.
	3	8	0	27,0	32,0	29,94		SE	1	Fair and frosty.
		2	0	36,0	34,0	29,84		SE	1	Fair and frosty.
	4	8	0	37,0	35,5	29,72	0,169	W by N	1	Cloudy.
		2	0	37,0	37,5	29,77		WNW	1	Foggy.
	5	8	0	35,5	37,0	29,80		ENE	1	Cloudy.
		2	0	36,0	37,5	29,91		NE	1	Cloudy.
	6	8	0	35,5	35,5	30,31		SE	1	Cloudy.
		2	0	37,0	37,5	30,31		NE	1	Fair.
	7	8	0	34,0	37,5	30,28		SW	1	Cloudy.
		2	0	34,0	39,0	30,26		SW	1	Cloudy.
	8	8	0	32,0	35,5	30,26		NE	1	Cloudy.
		2	0	35,0	35,5	30,27		NE	1	Fair.
	9	8	0	32,5	35,0	30,32		NE	1	Fair.
		2	0	33,0	34,5	30,30		NE	1	Fair.
	10	8	0	35,0	35,5	30,16		ENE	1	Fair.
		2	0	37,0	36,5	30,07		NW	1	Fair.
	11	8	0	32,5	35,0	29,99		NE	1	Fair.
		2	0	35,5	36,0	29,92		NE	1	Snow.
	12	8	0	33,0	35,0	29,63		ESE	1	Snow.
		2	0	38,0	37,5	29,57		ESE	1	Fine.
	13	8	0	33,5	36,0	29,43	0,222	SE	1	Snow.
		2	0	35,5	38,5	29,35		SE	1	Fair.
	14	8	0	33,5	37,0	28,87	0,095	E by S	2	Cloudy.
		2	0	37,0	39,0	28,59		ESE	1	Rain.
	15	8	0	40,0	41,0	28,68	0,139	S by E	1	Fair.
		2	0	45,0	42,5	28,76		SE	1	Rain.
	16	8	0	44,0	44,0	29,06	0,116	SSW	1	Cloudy.
		2	0	48,0	46,5	29,19		SW	1	Fair.

METE-

METEOROLOGICAL JOURNAL
for January 1778.

	Time. H.	M.	Therm. without	Therm within.	Barom. Inches.	Rain. Inch.	Winds. Points.	Str.	Weather.
Jan. 17	8	0	40,0	45,5	29,50	0,118	SSW	1	Fair.
	2	0	48,0	48,5	29,52		SW	1	Fine.
18	8	0	35,0	43,5	29,58		SE	1	Foggy.
	2	0	45,0	45,0	29,48		S by E	1	Fair.
19	8	0	44,0	44,0	29,21	0,167	SW	1	Cloudy.
	2	0	46,0	46,5	29,29		SW	2	Fair.
20	8	0	43,0	45,0	29,44	0,147	SW	2	Fair.
	2	0	44,5	48,5	29,49		SW	2	Fine.
21	8	0	40,0	45,0	29,09	0,297	SW	1	Cloudy.
	2	0	46,0	47,5	29,20		SW	1	Cloudy.
22	8	0	39,0	44,0	29,01		SSW	1	Fair.
	2	0	44,0	44,5	28,95		SW	1	Fine.
23	8	0	41,0	44,0	29,45	0,060	SW	1	Foggy.
	2	0	45,0	40,0	29,49		SW	1	Cloudy.
24	8	0	39,0	44,0	29,38	0,020	NE by N	1	Cloudy.
	2	0	42,0	45,0	29,41		NE	1	Cloudy.
25	8	0	35,5	40,0	29,39	0,435	NE	2	Rain.
	2	0	35,0	40,0	29,55		NE	3	Rain and snow.
26	8	0	30,0	38,0	30,21	0,126	N by E	1	Fair and frosty.
	2	0	36,0	38,0	30,28		NE	1	Fine.
27	8	0	25,0	32,5	30,14		NE	1	Fair and frosty.
	2	0	32,0	33,0	30,01		NE	1	Fine.
28	8	0	22,0	30,0	30,03		SW	1	Frosty.
	2	0	32,5	31,5	30,13		WSW	1	Cloudy.
29	8	0	34,5	33,0	30,08		S by W	1	Fair.
	2	0	40,5	35,0	30,11		NW	1	Foggy.
30	8	0	37,0	37,0	30,16		S by E	1	Cloudy.
	2	0	43,0	39,0	30,13		SW by W	1	Fine.
31	8	0	33,0	36,5	30,13		E	1	Foggy.
	2	0	39,0	38,0	30,11		SE	1	Cloudy.

METEOROLOGICAL JOURNAL.

for February 1778.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points.	Str.	
Feb. 1	8	0	35,5	37,5	30,16	0,012	NE	1	Cloudy.
	2	0	38,0	40,0	30,18		NE	1	Cloudy.
2	8	0	34,5	37,5	30,21		NE	1	Cloudy.
	2	0	36,0	37,5	30,24		NE	1	Cloudy.
3	8	0	35,0	37,5	30,24		SE	1	Cloudy.
	2	0	38,0	40,0	30,32		SE	1	Cloudy.
4	8	0	37,0	40,0	30,22		SE	1	Cloudy.
	2	0	37,5	41,0	30,13		SE	1	Cloudy.
5	8	0	34,5	38,5	29,53		SE	1	Cloudy.
	2	0	41,0	40,0	29,86		SE	1	Fair.
6	8	0	38,5	39,5	29,64		E by N	1	Foggy.
	2	0	47,0	41,5	29,52		E by N	1	Fine.
7	8	0	44,0	43,0	29,52		SE	1	Cloudy.
	2	0	48,0	44,5	29,67		SE	1	Fair.
8	8	0	40,0	43,0	29,86	0,047	SW	1	Fair.
	2	0	48,0	45,0	29,75		SSW	2	Fine.
9	8	0	40,0	44,5	29,84		E	1	Cloudy.
	2	0	48,0	46,5	29,95		E	1	Fine.
10	8	0	34,5	41,5	30,09		E by N	1	Foggy.
	2	0	37,0	44,5	30,07		E by N	1	Cloudy.
11	8	0	35,0	40,0	30,25		NE by E	1	Cloudy.
	2	0	37,0	41,5	30,22		NE	1	Fair.
12	8	0	34,0	38,5	30,35		NE	1	Cloudy.
	2	0	36,0	39,0	30,35		NE	1	Fair.
13	8	0	33,0	38,0	30,35		SW	1	Fair.
	2	0	35,0	41,0	30,33		SW	1	Fine.
14	8	0	38,0	40,0	29,80	0,050	WSW	1	Fair.
	2	0	43,5	43,0	29,56		WSW	1	Rain.
15	8	0	33,5	38,0	29,46	0,038	NW	1	Fine.
	2	0	32,0	40,0	29,37		NW	1	Fine.
16	8	0	33,0	38,0	29,23	0,016	N by W	1	Cloudy.
	2	0	33,5	38,5	29,16		NNW	1	Snow and rain.

METE-

METEOROLOGICAL JOURNAL
for February 1778.

	Time.	Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H. M.			Inches.	Inch.	Points.	Str.	
Feb. 17	8 0	33,0	36,5	29,39	0,045	N	1	Fair.
	2 0	35,0	38,5	29,39		N	1	Snow.
18	8 0	31,5	35,5	29,51	0,050	N by W	1	Snow.
	2 0	35,5	38,0	29,51		NW	1	Fine.
19	8 0	27,5	34,5	29,67		N by W	1	Fair.
	2 0	36,0	36,0	29,69		NW	1	Fine.
20	8 0	33,5	36,5	29,69		NW	1	Cloudy.
	2 0	40,0	38,5	29,74		NW	1	Cloudy.
21	8 0	41,0	40,0	29,99	0,070	W	1	Foggy.
	2 0	49,0	43,0	30,05		W	1	Rain.
22	8 0	46,0	45,0	29,99	0,010	WSW	1	Fair.
	2 0	52,0	47,5	29,96		WSW	1	Fine.
23	8 0	49,0	48,0	29,59		SW	2	Cloudy.
	2 0	48,0	48,0	29,59		SW	2	Fair.
24	8 0	35,0	40,0	29,27	0,072	WSW	2	Fair.
	2 0	46,0	43,5	29,29		SW	2	Fine.
25	8 0	36,0	39,5	29,23		NNW	2	Fair.
	2 0	35,0	39,0	29,38		NNW	2	Rain.
26	8 0	39,5	34,0	29,62	0,020	NNW	2	Fine.
	2 0	35,5	35,5	29,68		N by W	2	Fine.
27	8 0	25,5	32,5	29,78		S by W	1	Fair and frosty.
	2 0	35,0	38,0	29,59		SW	1	Fair.
28	8 0	37,0	35,0	29,15	0,097	W by S	1	Fair.
	2 0	44,0	37,0	29,19		NW	1	Fine.

METEOROLOGICAL JOURNAL
for March 1778.

	Time. H.	M.	Therm. without	Therm. within.	Barom. Inches.	Rain. Inch.	Winds. Points.	Str.	Weather.
Mar. 1	8	0	31,5	36,0	29,17		ENE	1	Fair and frosty.
	2	0	44,0	38,0	29,17		SE	1	Fine.
2	8	0	35,5	38,0	29,21	0,326	NNE	1	Rain.
	2	0	41,0	40,0	29,18		NE	1	Fair.
3	7	0	34,5	38,0	29,27		NE by N	1	Fair.
	2	0	42,0	40,0	29,34		NE	1	Fine.
4	7	0	36,0	38,0	29,42		NNW	1	Fair.
	2	0	40,0	40,0	29,46		NW	1	Fair.
5	7	0	34,0	37,0	29,37		NE by N	1	Fair.
	2	0	40,0	39,0	29,37		NE	1	Rain.
6	7	0	34,5	38,0	29,43		WNW	1	Fair.
	2	0	41,0	40,0	29,54		NW	1	Fair.
7	7	0	36,0	39,0	29,75	0,037	NE by N	1	Rain.
	2	0	40,0	40,0	29,76		NE	1	Fair.
8	7	0	35,5	38,0	29,69	0,055	NE	1	Rain.
	2	0	40,0	39,5	29,70		ENE	1	Cloudy.
9	7	0	36,0	38,5	29,73		NE	1	Cloudy.
	2	0	39,0	41,0	29,75		NE	1	Fair.
10	7	0	37,0	38,5	29,72		NW	1	Fair.
	2	0	42,0	42,5	29,78		NW	1	Fair.
11	7	0	39,0	41,0	29,94		ENE	1	Cloudy.
	2	0	40,0	45,0	30,00		NE	1	Fair.
12	7	0	38,5	42,0	30,21		ENE	1	Fair.
	2	0	41,0	42,5	30,27		NE	1	Fair.
13	7	0	32,5	39,0	30,36		NE by E	1	Fine.
	2	0	45,0	41,0	30,43		NE	1	Fine.
14	7	0	26,0	35,0	30,38		N	1	Fair.
	2	0	41,0	39,0	30,31		NNE	1	Fine.
15	7	0	36,0	38,0	30,26		ENE	1	Fair.
	2	0	42,5	39,5	30,22		ENE	1	Fair.
16	7	0	37,5	39,0	30,19		NE	1	Fair.
	2	0	40,0	41,5	30,19		NE	1	Fair.

METEOROLOGICAL JOURNAL for March 1778.

	Time. H.	M.	Therm. without	Therm. within.	Barom. Inches.	Rain. Inch.	Winds. Points.	Str.	Weather.
Mar. 17	7	0	36,0	40,0	30,16		SE	1	Fair.
	2	0	49,0	44,5	30,16		SE	1	Fine.
18	7	0	38,0	42,0	30,03		SW	1	Fine.
	2	0	57,0	47,0	30,01		SW	1	Fine.
19	7	0	41,5	46,0	29,97		SSW	1	Fair.
	2	0	48,0	48,5	29,88		NW	1	Fine.
20	7	0	38,0	45,0	29,59		E by N	1	Fair.
	2	0	45,0	47,0	29,53		E by N	1	Fair.
21	7	0	32,0	47,0	29,50		SW by S	1	Fair.
	2	0	57,0	49,0	29,50		SW	1	Fine.
22	7	0	49,0	50,0	29,25	0,152	SW	2	Fine.
	2	0	55,5	52,5	29,22		SW	2	Fine.
23	7	0	48,0	51,0	29,13	0,020	SW	1	Rain.
	2	0	51,5	52,5	29,02		WSW	2	Cloudy.
24	7	0	42,0	49,0	29,25	0,271	SW	1	Fine.
	2	0	47,5	50,0	29,17		SSW	2	Rain.
25	7	0	37,5	46,5	29,21	0,220	NNE	2	Cloudy.
	2	0	44,0	46,5	29,46		NNE	2	Fine.
26	7	0	34,0	40,5	30,00		NNW	1	Fine.
	2	0	46,5	43,0	30,12		SW	1	Fine.
27	7	0	39,0	41,0	30,22		SW	1	Fine.
	2	0	49,0	44,0	30,24		SW	1	Fine.
28	7	0	41,0	43,0	30,12		SSE	2	Rain.
	2	0	45,0	44,0	30,09		SW	2	Rain.
29	7	0	49,0	46,0	30,04	0,150	S by E	1	Fair.
	2	0	60,0	50,0	30,06		S by E	1	Fine.
30	7	0	51,0	50,0	29,94		SW	1	Fair.
	2	0	57,0	53,0	29,91		SW	1	Fair.
31	7	0	53,0	54,0	29,89	0,012	WSW	1	Fair.
	2	0	60,0	58,0	29,93		SW	1	Fine.

METEOROLOGICAL JOURNAL

for April 1778.

	Time. H.	M.	Therm. without	Therm. within.	Barom. Inches	Rain. Inch.	Winds, Points.	Str.	Weather.
April 1	7	0	50,5	53,5	29,96	0,055	SW	1	Fair.
	2	0	55,0	55,5	29,93		SW	1	Fine.
2	7	0	48,0	51,0	29,81		SE	1	Fair.
	2	0	65,0	55,0	29,89		SE	1	Fine.
3	7	0	48,5	54,0	29,40		SW	1	Fair.
	2	0	57,0	60,0	29,56		SW	1	Fine.
4	7	0	49,5	54,5	29,52	0,048	SW bW	1	Fair.
	2	0	58,5	57,5	29,57		S by W	2	Fine.
5	7	0	45,0	52,0	29,82	0,163	SSW	2	Fine.
	2	0	57,5	54,0	29,84		SSW	2	Fine.
6	7	0	47,5	52,0	29,82		SSW	2	Fine.
	2	0	58,5	55,0	29,82		SW	2	Fine.
7	7	0	49,0	53,0	30,03	0,032	NW	1	Rain.
	2	0	59,0	56,0	30,16		NW	1	Fair.
8	7	0	46,0	52,0	30,20		NE	1	Fair.
	2	0	61,0	56,0	30,13		ESE	1	Fine.
9	7	0	50,5	53,0	30,03		NE by E	1	Fine.
	2	0	66,0	61,0	30,02		ESE	1	Fine.
10	7	0	49,5	55,0	30,14		NE by N	1	Fine.
	2	0	69,5	60,0	30,20		NE	1	Fine.
11	7	0	48,0	57,0	30,23		NE	1	Fine.
	2	0	69,0	60,0	30,24		NE	1	Fine.
12	7	0	50,0	57,0	30,23		SSW	1	Fine.
	2	0	71,5	63,0	30,17		NNW	1	Fine.
13	7	0	51,0	58,0	30,01		NNW	1	Fair.
	2	0	67,5	62,0	29,87		NW	1	Fine.
14	7	0	42,5	53,0	29,82	0,029	NW bW	2	Fine.
	2	0	59,0	52,0	29,79		NW	2	Fine.
15	7	0	39,0	45,5	29,67	0,016	NW bN	2	Fair.
	2	0	57,0	45,0	29,62		NW	2	Fine.
16	7	0	34,5	43,0	29,59		NW bW	1	Fine.
	2	0	48,0	47,5	29,65		NW	1	Fine.

METEOROLOGICAL JOURNAL
for April 1778.

	Time.	Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H. M.			Inches.	Inch.	Points.	Str.	
Apr. 17	7 0	41,0	45,0	29,64	0,026	SW	1	Fair.
	2 0	51,0	49,5	29,61		SW	1	Fine.
18	7 0	40,0	46,0	29,81	0,023	SW by S	1	Fine.
	2 0	54,0	51,0	29,95		SW	1	Fine.
19	7 0	47,0	47,5	29,94		SW by W	1	Fair.
	2 0	59,0	52,0	29,89		SW	1	Fine.
20	7 0	44,0	50,0	29,71	0,119	W by N	1	Fine.
	2 0	56,0	54,0	29,66		NNW	1	Fine.
21	7 0	41,0	47,0	29,44	0,030	NW	1	Fine.
	2 0	45,0	50,0	29,48		NW	1	Fair.
22	7 0	37,0	44,0	29,56	0,040	N by W	2	Fair.
	2 0	40,0	46,0	29,65		NW	2	Rain.
23	7 0	39,5	42,5	29,72	0,023	N by W	1	Fine.
	2 0	47,0	46,0	29,73		NW	1	Fine.
24	7 0	36,0	42,0	29,74		N by E	1	Fine.
	2 0	47,0	46,5	29,78		NE	1	Fine.
25	7 0	42,0	44,0	29,89		NE	1	Fine.
	2 0	51,5	48,5	29,91		NE	1	Fine.
26	7 0	39,5	43,5	29,73		ENE	1	Fine.
	2 0	52,5	47,0	29,65		NE	1	Fine.
27	7 0	41,0	45,0	29,45	0,025	NE	1	Rain.
	2 0	52,0	50,0	29,51		NE	1	Fair.
28	7 0	44,5	47,0	29,50	0,045	ENE	1	Fair.
	2 0	51,0	50,5	29,51		NE	1	Cloudy.
29	7 0	44,0	48,0	29,48	0,010	ENE	1	Fair.
	2 0	53,5	52,0	29,39		NE	1	Fine.
30	7 0	46,0	49,5	29,30	0,110	NE	1	Fair.
	2 0	58,0	53,0	29,32		NE	1	Fine.

METEOROLOGICAL JOURNAL
for May 1778.

	Time. H.	Time. M.	Therm. without	Therm. within.	Barom. Inches.	Rain. Inch.	Winds. Points.	Winds. Str.	Weather.
May 1	7	0	49,0	51,0	29,34		ENE	1	Cloudy.
	2	0	52,5	33,5	29,43		E by S	1	Rain.
2	7	0	50,0	53,0	29,61	0,327	S by E	1	Fine.
	2	0	58,5	55,0	29,62		S by E	1	Rain.
3	7	0	51,0	54,0	29,65	0,135	E by S	1	Rain.
	2	0	61,0	57,5	29,54		SE	1	Rain.
4	7	0	53,0	56,0	29,55	0,124	SSW	1	Rain.
	2	0	65,0	62,5	29,61		SW	1	Fine.
5	7	0	54,0	57,0	29,74		SSW	1	Fair.
	2	0	61,5	59,0	29,94		SW	1	Fine.
6	7	0	50,0	55,5	29,98	0,038	S by E	1	Fair.
	2	0	59,0	57,5	29,95		SE	2	Fair.
7	7	0	54,0	56,5	29,82	0,020	S by W	2	Cloudy.
	2	0	61,5	58,5	29,85		SW	1	Fine.
8	7	0	52,5	56,0	29,94	0,012	S by E	1	Fine.
	2	0	61,0	59,0	29,94		SE	1	Cloudy.
9	7	0	53,0	54,0	29,91		S by W	1	Fair.
	2	0	58,5	58,0	29,96		SW b W	2	Cloudy.
10	7	0	50,0	55,0	30,20	0,036	SW	1	Fine.
	2	0	66,0	59,0	30,20		SW	1	Fine.
11	7	0	54,5	56,0	30,10		SW by S	1	Fine.
	2	0	67,0	64,5	30,03		SW	1	Fine.
12	7	0	56,5	58,0	29,70		SW	1	Fine.
	2	0	65,5	63,0	29,66		SW	2	Fine.
13	7	0	53,0	59,0	29,55	0,034	S by E	1	Rain.
	2	0	64,5	62,0	29,59		SW	1	Fine.
14	7	0	55,0	59,5	29,65	0,010	S by E	2	Fine.
	2	0	67,0	61,5	29,79		S by E	2	Fine.
15	7	0	52,5	59,0	30,03	0,010	S by W	1	Fine.
	2	0	63,5	61,0	30,04		SW	1	Fine.
16	7	0	55,5	59,0	29,97		S by W	1	Cloudy.
	2	0	68,0	61,5	29,99		SW	1	Fine.

METEOROLOGICAL JOURNAL for May 1778.

	Time.	Therm. without	Therm. within	Barom.	Rain.	Winds.		Weather.
	H. M.			Inches.	Inch.	Points.	Str.	
May 17	7 0	54,0	58,5	29,73	0,075	SW	2	Cloudy.
	2 0	59,0	61,5	29,67		SW	3	Cloudy.
18	7 0	51,0	58,0	29,68	0,114	SW	2	Fine.
	2 0	61,5	59,5	29,75		SW	2	Fine.
19	7 0	52,0	56,0	30,00		WSW	1	Fine.
	2 0	63,0	60,0	30,14		SW	1	Fine.
20	7 0	53,0	57,0	30,27		WSW	1	Fair.
	2 0	62,5	59,0	30,28		WSW	1	Fair.
21	7 0	55,0	58,0	30,24		NNE	1	Cloudy.
	2 0	66,0	61,0	30,20		NE	1	Fine.
22	7 0	54,5	60,0	29,96		W by S	1	Fair.
	2 0	58,5	59,5	29,92		NW b N	1	Rain.
23	7 0	50,5	57,0	30,07	0,074	NNW	1	Fair.
	2 0	60,0	58,0	30,12		NW	1	Fine.
24	7 0	51,5	56,0	30,08		SSW	1	Fine.
	2 0	62,0	57,0	30,05		SW	1	Fine.
25	7 0	51,0	54,5	29,41		NE	1	Fair.
	2 0	58,0	56,0	29,76		NE	1	Fine.
26	7 0	53,0	56,5	29,91		N by W	1	Fine.
	2 0	66,0	61,5	29,98		NE	1	Fine.
27	7 0	56,0	60,0	29,88	0,042	W by N	1	Cloudy.
	2 0	63,0	62,0	29,88		WNW	1	Fair.
28	7 0	54,0	59,0	30,03	0,052	NW	1	Fine.
	2 0	65,0	61,0	30,11		NW	1	Fine.
29	7 0	57,0	60,0	30,08		NW	1	Cloudy.
	2 0	68,5	64,0	30,03		NW	1	Fine.
30	7 0	56,0	61,5	30,07		NE	1	Fine.
	2 0	71,5	65,0	30,02		SW	1	Fair.
31	7 0	57,0	62,0	30,00		SSW	1	Fair.
	2 0	66,0	64,0	30,04		NE	1	Cloudy.

METEOROLOGICAL JOURNAL
for June 1778.

	Time.	Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H. M.			Inches	Inch.	Points.	Str.	
June 1	7 0	57,5	63,0	30,03		SSW	1	Fine.
	2 0	72,0	67,0	30,03		SW	1	Fine.
2	7 0	57,0	61,0	30,06		SW	2	Fine.
	2 0	66,5	63,0	30,02		SW	2	Fine.
3	7 0	52,0	60,0	29,84	0,012	SW	1	Fine.
	2 0	62,0	61,5	29,84		SSW	1	Fine.
4	7 0	53,5	60,0	29,75		SSW	1	Fine.
	2 0	59,0	61,0	29,75		SW	1	Fine.
5	7 0	51,0	58,5	29,82	0,305	SW	1	Fine.
	2 0	61,5	61,5	29,88		SW	1	Fine.
6	7 0	59,5	60,5	29,79		SSW	1	Fine.
	2 0	73,0	63,5	29,75		SW	2	Fine.
7	7 0	58,0	63,0	29,64		WSW	1	Fair.
	2 0	69,0	65,0	29,71		SW	1	Fine.
8	7 0	56,5	62,0	29,85		SW	1	Fine.
	2 0	68,5	65,5	29,93		SW	1	Fine.
9	7 0	57,0	62,0	30,07		SW	1	Fair.
	2 0	58,0	61,5	30,10		SW	1	Rain.
10	7 0	55,5	62,0	30,17	0,220	W by S	1	Fine.
	2 0	70,5	66,0	30,17		SSW	1	Fine.
11	7 0	59,5	60,0	30,14		SSW	1	Fair.
	2 0	72,0	67,0	30,19		SW	1	Fine.
12	7 0	64,0	66,0	30,16		SW	1	Fine.
	2 0	78,5	71,5	30,19		SW	1	Fine.
13	7 0	63,0	68,5	30,16		SSW	1	Fair.
	2 0	71,5	70,0	30,24		SW	1	Fine.
14	7 0	60,0	66,0	30,36		N by E	1	Fine.
	2 0	70,0	68,5	30,36		NE	1	Fine.
15	7 0	53,5	65,0	30,25	0,140	NNW	1	Fine.
	2 0	63,0	63,5	30,19		NW	1	Fine.
16	7 0	54,0	61,0	30,15	0,016	W by N	1	Fair.
	2 0	64,0	62,0	30,18		NW	1	Fine.

METEOROLOGICAL JOURNAL for June 1778.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points.	Str.	
June 17	7	0	58,5	61,0	30,12		SW	1	Fair.
	2	0	58,0	55,8	30,12		SW	1	Fair.
18	7	0	62,0	64,0	30,03	0,264	N by W	1	Fair.
	2	0	72,0	66,5	30,02		N by W	1	Fine.
19	7	0	63,5	66,5	30,09		N by E	1	Fair.
	2	0	73,5	71,0	30,13		NE	1	Fine.
20	7	0	62,0	67,0	30,18		NNE	1	Fair.
	2	0	74,0	70,3	30,22		NE	1	Fine.
21	7	0	62,0	67,0	30,29		SE	1	Fair.
	2	0	74,0	78,0	30,25		SW	1	Fine.
22	7	0	62,0	68,0	30,22		NW	1	Cloudy.
	2	0	76,5	72,0	30,21		NW	1	Fine.
23	7	0	62,5	70,0	30,22		N by W	1	Fine.
	2	0	76,0	72,5	30,17		NE	1	Fine.
24	7	0	64,5	68,5	30,08		E by N	1	Fair.
	2	0	73,5	72,5	30,02		E by N	2	Fine.
25	7	0	63,0	68,5	29,99		ENE	1	Fair.
	2	0	68,0	70,0	30,07		SW	1	Cloudy.
26	7	0	63,0	69,0	30,10	0,030	NW	1	Fine.
	2	0	78,5	72,0	30,16		NW	1	Fine.
27	7	0	66,5	70,0	30,06		SSE	1	Fine.
	2	0	82,0	75,5	30,14		SE	1	Fine.
28	7	0	63,5	70,0	29,86		SW	1	Fine.
	2	0	75,0	73,0	29,87		SW	1	Fine.
29	7	0	63,0	70,0	29,88		NNE	1	Fine.
	2	0	76,5	73,5	29,87		SW	1	Fine.
30	7	0	60,0	68,0	29,90	0,029	NE	1	Cloudy.
	2	0	77,5	73,0	29,93		NE	1	Fine.

METEOROLOGICAL JOURNAL for July 1778.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points.	Str.	
July 1	7	0	65,0	70,0	29,85		S by E	1	Cloudy.
	2	0	68,0	70,0	29,81		SE	1	Cloudy.
2	7	0	63,5	67,5	30,08		W	1	Fair.
	2	0	78,0	72,5	30,12		W	1	Fine.
3	7	0	63,0	69,0	30,01		S by W	1	Fine.
	2	0	75,0	72,5	29,98		SW	1	Fine.
4	7	0	65,0	70,0	30,02		S by W	1	Fair.
	2	0	78,0	73,0	30,08		SW	1	Fine.
5	7	0	70,5	72,0	29,96		ESE	1	Fine.
	2	0	82,0	78,5	29,95		SW	1	Fine.
6	7	0	67,5	76,0	30,00	0,204	W by S	1	Fine.
	2	0	78,0	76,0	30,05		SW	1	Fine.
7	7	0	61,5	72,5	30,04		NW b W	1	Fine.
	2	0	74,0	72,0	30,02		NW	1	Fair.
8	7	0	62,5	70,5	30,15		NW	1	Fine.
	2	0	73,5	72,5	30,24		NW	1	Fine.
9	7	0	63,0	66,0	30,28		NW	1	Fine.
	2	0	80,0	73,5	30,29		NW	1	Fine.
10	7	0	66,5	69,5	30,20		W	1	Fair.
	2	0	82,5	79,0	30,20		W by N	1	Fine.
11	7	0	66,0	75,0	30,19		NW	1	Fine.
	2	0	81,0	77,0	30,19		NW	1	Fine.
12	7	0	68,5	75,0	30,23		NW	1	Fair.
	2	0	79,0	76,0	30,26		NW	1	Fine.
13	7	0	72,5	77,0	30,26		ENE	1	Fine.
	2	0	86,0	81,0	30,19		SSW	1	Fine.
14	7	0	71,5	78,0	30,11		W by S	1	Fine.
	2	0	86,0	81,0	30,08		SW	1	Fine.
15	7	0	63,0	71,5	30,19		NE	1	Fair.
	2	0	77,5	76,5	30,23		NE	1	Fine.
16	7	0	67,0	72,0	30,11		SE	1	Fine.
	2	0	83,5	79,5	30,06		SW	1	Fine.

METEOROLOGICAL JOURNAL

for July 1778.

	Time.	Therm. without	Therm. within	Barom.	Rain.	Winds.		Weather.
	H. M.			Inches.	Inch.	Points.	Str.	
July 17	7 0	66,0	73,0	30,04		NNE	1	Fair.
	2 0	72,0	73,0	30,14		NE	1	Fair.
18	7 0	62,0	68,5	30,17		SE	1	Fine.
	2 0	78,0	72,0	30,12		ESE	1	Fair.
19	7 0	64,0	65,5	29,97		E by S	1	Fine and clear.
	2 0	78,0	72,0	29,94		SE	1	Clear.
20	7 0	66,5	73,0	29,57		NE	1	Clear, th. and l. last night.
	2 0	69,0	73,0	29,52		S by W	1	Much th. l. and heavy rain.
21	7 0	62,5	66,0	29,48	0,990	N by E	1	Fair.
	2 0	72,0	75,0	29,54		NE	1	Clear.
22	7 0	58,5	67,5	29,76	0,186	W by S	1	Cloudy.
	2 0	67,5	66,5	29,85		W by S	1	Cloudy.
23	7 0	61,0	65,5	29,67	0,165	SSW	2	Rain, much wind last n.
	2 0	62,0	66,5	29,72		SSW	1	Rainy.
24	7 0	57,0	64,5	29,72	0,175	SSW	1	Rain last night.
	2 0	59,0	66,0	29,69		SW	1	Much rain.
25	7 0	58,5	64,5	29,62	0,872	SE	2	Rainy.
	2 0	68,5	68,0	29,57		SE	2	Rainy.
26	7 0	60,0	64,5	29,78	0,209	SW	2	Fine, much wind last n.
	2 0	68,5	67,0	29,84		SW	2	Fine, after much w. & show.
27	7 0	61,5	65,5	29,82	0,015	S by W	1	Cloudy.
	2 0	74,0	68,5	29,82		SW	1	Fine.
28	7 0	64,0	67,0	29,72	0,082	SW	2	Cloudy, wind and n. last n.
	2 0	68,5	68,0	29,75		SW	2	Showery.
29	7 0	60,0	66,0	29,79	0,046	WSW	1	Fair.
	2 0	70,0	68,5	29,99		SW	1	Fine.
30	7 0	60,5	63,0	29,88		S by E	1	Cloudy.
	2 0	72,5	78,0	29,80		SE	1	Cloudy.
31	7 0	59,0	65,0	29,77	0,209	S by E	1	Cloudy.
	2 0	65,0	65,0	29,83		SW	1	Much rain, th. and lightn.

METEOROLOGICAL JOURNAL
for Auguſt 1778.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points	Str.	
Aug. 1	7	0	58,5	63,0	30,10	0,930	NNE	1	Cloudy.
	2	0	72,0	66,0	30,19		NE	1	Fine.
2	7	0	63,0	65,5	30,20		SW	1	Fine.
	2	0	74,5	68,5	30,22		SW	2	Fine.
3	7	0	63,0	68,0	30,23		SSW	1	Fine.
	2	0	76,0	72,0	30,25		SW	1	Fine.
4	7	0	67,0	70,0	30,14		S by W	1	Fair.
	2	0	80,0	73,5	30,07		SW	1	Fine.
5	7	0	63,5	68,5	29,93		SW	1	Fine.
	2	0	78,0	73,5	29,89		SW	1	Fine.
6	7	0	67,5	72,0	29,84		SW by W	1	Fair.
	2	0	75,0	73,5	29,87		SW	1	Fine.
7	7	0	67,5	69,5	29,88		SW	1	Cloudy.
	2	0	78,0	73,5	29,94		NW	1	Fine.
8	7	0	59,5	68,0	30,01		NNE	1	Cloudy.
	2	0	73,5	70 5	30,07		NE	1	Fine.
9	7	0	61,0	67,0	30,09		SW	1	Fine.
	2	0	74,5	70,5	30,09		SW	2	Cloudy.
10	7	0	62,5	69,0	30,11		W by S	1	Cloudy.
	2	0	76,0	72,5	30,14		NW	1	Fine.
11	7	0	64,5	70,5	30,03		SW	1	Cloudy.
	2	0	73,0	71,5	30,05		SW	2	Cloudy.
12	7	0	62,0	69,0	30,04		SW	1	Fine.
	2	0	75,0	72,5	30,08		SW	1	Fine.
13	7	0	63,5	69,0	29 91		SW	1	Cloudy.
	2	0	75,5	72,5	29,90		S by W	1	Fine.
14	7	0	65,0	69,5	29,59		SW	2	Fine.
	2	0	68,0	70,0	29,76		SW	2	Cloudy and much wind.
15	7	0	54,5	65,5	30,04	0,065	SW	1	Fine.
	2	0	70,0	68,5	30,15		SW	1	Fine.
16	7	0	56,5	59,5	30,33		NE	1	Fine.
	2	0	72,0	65,0	30,39		SW	1	Fine.

METE-

METEOROLOGICAL JOURNAL
for Auguſt 1778.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points.	Str.	
Aug. 17	7	0	56,0	63,5	30,40		NE by E	1	Fine.
	2	0	72,0	69,0	30,36		NE by E	1	Fine.
18	7	0	59,5	65,0	30,24		NE	1	Fine.
	2	0	78,0	71,0	30,21		NE	1	Fine.
19	7	0	60,0	66,5	30,20		NE	1	Fine.
	2	0	79,5	72,5	30,19		SSE	1	Fine.
20	7	0	57,0	68,0	30,19		SE	1	Fair.
	2	0	78,5	73,5	30,16		SW	1	Fine.
21	7	0	62,0	69,0	30,20		NE	1	Fine.
	2	0	78,5	72,0	30,17		SE	1	Fine.
22	7	0	60,0	68,5	30,10		NE by N	1	Cloudy.
	2	0	76,5	73,0	30,09		SSE	1	Fine.
23	7	0	62,0	69,0	30,19		W by S	1	Fine.
	2	0	78,0	73,5	30,28		W by N	1	Fine.
24	7	0	60,5	68,0	30,44		WNW	1	Fine.
	2	0	78,0	73,5	30,51		NW	1	Fine.
25	7	0	65,5	71,5	30,49		NW bW	1	Fine.
	2	0	82,0	76,5	30,45		SW	1	Fine.
26	7	0	60,5	65,0	30,35		NNE	1	Fair.
	2	0	70,0	70,5	30,37		NE	1	Cloudy.
27	7	0	56,0	65,0	30,36		NE by N	1	Fair.
	2	0	65,0	65,5	30,33		N by E	2	Cloudy.
28	7	0	55,0	61,5	30,40		NE	2	Fine.
	2	0	69,0	65,0	30,43		NE	2	Fine.
29	7	0	52,0	60,5	30,44		N by W	1	Fine.
	2	0	66,0	63,5	30,38		NW	1	Fine.
30	7	0	55,0	61,0	30,08		WSW	1	Fine.
	2	0	68,0	64,5	29,98		W by N	1	Cloudy.
31	7	0	47,0	57,5	30,03	0,044	NW	1	Fine.
	2	0	61,0	59,5	30,14		NW	2	Fine.

METEOROLOGICAL JOURNAL
for September 1778.

	Time. H.	M.	Therm. without	Therm. within.	Barom. Inches.	Rain. Inch.	Winds. Points.	Str.	Weather.
Sept. 1	7	0	44,5	55,0	30,13		SW	1	Fair.
	2	0	64,0	59,0	30,09		SW	1	Fine.
2	7	0	55,5	58,5	29,90		WNW	1	Rain.
	2	0	63,0	61,5	29,94		NW	1	Cloudy.
3	7	0	55,5	60,0	29,88	0,027	N by W	1	Cloudy.
	2	0	67,0	63,5	29,86		NW	1	Cloudy.
4	7	0	49,0	60,0	30,01		NE	1	Fine.
	2	0	65,0	62,0	29,98		NW	1	Fine.
5	7	0	50,0	59,0	30,00	0,015	NE by E	1	Fine.
	2	0	63,5	61,5	30,01		NW	1	Fine.
6	7	0	47,0	53,5	30,01		NE	1	Fine.
	2	0	64,5	59,5	29,99		NE	1	Cloudy.
7	7	0	56,0	58,0	29,87		NE	1	Cloudy.
	2	0	61,0	61,5	29,85		NE	1	Rainy.
8	7	0	53,5	59,5	29,95	0,024	NNE	1	Fine.
	2	0	68,0	63,5	30,03		NE	1	Fine.
9	7	0	52,0	59,0	30,09		NNE	1	Cloudy.
	2	0	64,5	62,0	30,05		ENE	1	Fine.
10	7	0	52,5	59,0	29,98		NE	1	Cloudy.
	2	0	65,0	62,5	29,93		SE	1	Fine.
11	7	0	55,5	59,5	29,54		E	1	Cloudy.
	2	0	54,0	60,5	29,48		NE	1	Rainy.
12	7	0	53,0	58,0	29,48	0,375	SW	1	Fair.
	2	0	61,5	61,0	29,50		W by N	2	Fine.
13	7	0	47,0	57,0	29,68	0,015	W by N	1	Fine.
	2	0	63,5	60,5	29,78		NW	1	Fine.
14	7	0	45,5	56,0	30,05		NE	1	Fair.
	2	0	63,5	59,0	30,15		NE	1	Fine.
15	7	0	46,5	54,5	30,23		NE	1	Fine.
	2	0	66,0	59,5	30,20		SE	1	Fine.
16	7	0	48,0	56,0	29,96		S by E	1	Fine.
	2	0	66,5	62,0	29,80		SE	1	Cloudy.

METEOROLOGICAL JOURNAL
for September 1778.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points.	Str.	
Sept. 17	7	0	46,0	56,0	29,86	0,146	SSW	1	Fine.
	2	0	60,0	59,0	29,89		SW	1	Fine.
18	7	0	43,5	53,5	30,04		SW by S	1	Fine.
	2	0	63,0	57,5	30,09		WNW	1	Fine.
19	7	0	51,0	56,5	30,27		SW	1	Fine.
	2	0	66,5	60,0	30,30		WSW	1	Fine.
20	7	0	50,5	56,5	30,42		ENE	1	Fine.
	2	0	68,0	62,0	30,40		S	1	Fine.
21	7	0	49,5	57,0	30,42		NE	1	Fair.
	2	0	67,5	62,0	30,42		NE by E	1	Fine.
22	7	0	53,0	58,0	30,38		NE by N	1	Cloudy.
	2	0	69,0	67,5	30,39		NE	1	Fine.
23	7	0	58,5	62,5	30,26		E by N	1	Cloudy.
	2	0	71,0	67,5	30,21		NE	1	Fine.
24	7	0	52,0	62,5	29 99		SSW	1	Fair.
	2	0	67,5	65,0	29,99		NNW	1	Fine.
25	7	0	48,0	58,5	29,98		NNE	1	Fair.
	2	0	69,5	60,5	29,94		NE	1	Fine.
26	7	0	47,0	56,0	29,62		NE	1	Cloudy.
	2	0	58,5	57,5	29,45		SSE	1	Cloudy.
27	7	0	49,0	56,0	29,15	0,100	NNE	1	Cloudy.
	2	0	49,5	56,0	29,27		N by W	2	Rainy.
28	7	0	37,0	49,0	29,94	0,033	W by S	1	Fine.
	2	0	51,0	50,5	30,07		W by S	1	Fine.
29	7	0	36,5	47,0	30,27		S by W	1	Fair.
	2	0	53,5	50,0	30,30		SW	1	Fine.
30	7	0	45,5	49,0	30,03		SW	1	Fine.
	2	0	57,0	52,0	29,86		SSW	2	Fine.

METEOROLOGICAL JOURNAL
for October 1778.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points	Str.	
Oct. 1	7	0	48,0	52,0	29,47	0,147	SSW	1	Fine.
	2	0	56,5	55.5	29,42		SW	1	Showery.
2	7	0	47,0	52,5	29 37	0,132	WSW	1	Fine.
	2	0	54,5	54,5	29,41		SW	1	Showery.
3	7	0	41,0	50,5	29,34	0,040	SW	1	Fair.
	2	0	54,5	53,0	29,36		NW	1	Fine.
4	7	0	41,0	50,0	29,50		SSW	1	Fair.
	2	0	54,0	52,5	29,58		NW	1	Cloudy and showery.
5	7	0	42,0	50,0	29,66		N by W	1	Fair.
	2	0	57,0	53,5	29,69		NW	1	Fair.
6	7	0	44.0	50,5	29,60		NE by E	1	Cloudy.
	2	0	54,5	52,5	29,54		NE	1	Cloudy.
7	7	0	55,0	54,0	29,30	0,543	ENE	1	Rainy.
	2	0	64,5	68,5	29,27		ENE	1	Cloudy.
8	7	0	54,0	58,0	29,30	0,560	SSE	1	Fine.
	2	0	61,5	67,0	29,29		NE	1	Fine.
9	7	0	48,0	56,5	29,38	0,052	NE	1	Cloudy.
	2	0	59,0	59,0	29,38		NE	1	Fine.
10	7	0	52,0	57,0	29,40	0,207	NW bN	1	Cloudy.
	2	0	51,0	56,5	29,60		NE	1	Rainy.
11	7	0	38,5	50,5	29,75	0,010	WNW	1	Fine.
	2	0	51,0	51,5	29,76		NW	1	Fine.
12	7	0	34,0	46,0	29,91		W by N	1	Fair.
	2	0	51,0	48,5	29,96		W by N	1	Fine.
13	7	0	40,0	46,0	29,89		NE	1	Fair.
	2	0	53,0	49,0	29,85		NE	1	Fair.
14	7	0	35,5	45,5	29,72		NW	1	Fine.
	2	0	51,0	49,0	29,70		NW	2	Fine.
15	7	0	38,5	45,0	29 64		NE by N	1	Fine.
	2	0	61,0	59,5	29,79		N	1	Cloudy.
16	7	0	36,5	40,5	29,86		N	1	Fine.
	2	0	49,0	45,5	29,92		NE	1	Fair.

METEOROLOGICAL JOURNAL
for October 1778.

	Time. H.	M.	Therm. without	Therm. within.	Barom. Inches	Rain. Inch.	Winds. Points.	Str.	Weather.
Oct. 17	7	0	32,0	41,0	30,00		NNE	1	Fine.
	2	0	47,0	44,0	29,98		N by E	1	Fine.
18	7	0	31,5	40,0	29,98		S by E	1	Fair and frosty.
	2	0	50,0	43,5	30,00		SE	1	Fine.
19	7	0	33,5	40,5	29,90		NE by N	1	Fine.
	2	0	47,0	43,0	29,81		NE	1	Fine.
20	7	0	40,0	41,5	29,44		NE	1	Fair.
	2	0	49,0	45,0	29,44		NE	1	Cloudy.
21	7	0	39,5	43,5	29,52	0,025	WSW	1	Foggy.
	2	0	55,0	49 0	29,58		SW	1	Fine.
22	7	0	41,5	47,0	29,64	0,028	SW	1	Fine.
	2	0	53,0	49,0	29,75		SW	1	Fine.
23	7	0	54,5	50,0	29,31	0,320	S by E	2	Rainy.
	2	0	59,0	54,0	29,21		SW	2	Rainy.
24	7	0	54,5	54,5	29,18	0,465	NW	2	Rainy.
	2	0	61,5	57,0	29,17		NW	2	Showery.
25	7	0	52,5	56,5	29,20	0,133	SW by W	2	Cloudy.
	2	0	45,0	55,0	29,31		NE	1	Rainy.
26	7	0	33,5	47,0	29,79	0,037	NW b N	1	Fine.
	2	0	45,0	47,5	29,89		NW	1	Fine.
27	7	0	34,0	42,0	29,90		NE by N	1	Fair.
	2	0	47,0	45,0	29,89		NW	1	Fine.
28	7	0	45,0	44,5	29,74		ESE	1	Cloudy.
	2	0	54,0	51,0	29,72		ESE	1	Cloudy.
29	7	0	52,0	49,0	29,60	0,111	SSE	1	Cloudy.
	2	0	56,5	53,0	29,79		SE	1	Cloudy.
30	7	0	49,5	52,0	30,02	0,060	SW by W	1	Fair.
	2	0	55,0	53,0	30,16		SW	2	Fair.
31	7	0	52,0	52,5	29,84	0,033	NW	2	Cloudy.
	2	0	57,5	55,0	29,69		SW	3	Cloudy.

METEOROLOGICAL JOURNAL
for November 1778.

	Time. H.	M.	Therm. without	Therm. within.	Barom. Inches	Rain. Inch.	Winds. Points.	Str.	Weather.
Nov. 1	8	0	45,5	51,0	30,00	0,015	WSW	2	Fine.
	2	0	54,5	51,5	30,11		NW	2	Fine.
2	8	0	45,0	50,0	30,24		W by S	1	Fine.
	2	0	55,0	52,0	30,27		SW	1	Fine.
3	8	0	45,0	49,0	29,93		SE	1	Cloudy.
	2	0	53,5	51,5	29,79		SSE	1	Fine.
4	8	0	52,0	51,5	29,49	0,034	NE	1	Cloudy.
	2	0	47,0	51,5	29,62		SW	1	Rainy.
5	8	0	36,0	46,0	29,54	0,310	SW	1	Cloudy.
	2	0	48,0	47,5	29,36		NE	1	Cloudy.
6	8	0	44,5	48,0	29,25	0,356	SE	1	Fair.
	2	0	51,5	49,5	29,25		SE	1	Cloudy.
7	8	0	46,0	48,5	29,36	0,562	SW b W	2	Fair.
	2	0	50,0	50,0	29,50		SW	2	Fine.
8	8	0	41,0	46,5	29,44	0,143	W by S	1	Cloudy.
	2	0	46,0	47,5	29,55		NW	1	Fine.
9	8	0	39,0	45,0	29,66		S by W	1	Fair.
	2	0	46,0	47,0	29,49		SE	1	Rainy.
10	8	0	42,5	46,0	29,40	0,333	W by S	1	Fair.
	2	0	47,0	47,0	29,51		NW	1	Fair.
11	8	0	45,5	45,0	28,95	0,140	SE	2	Rainy.
	2	0	41,0	46,0	29,07		SE	2	Cloudy.
12	8	0	32,5	42,5	29,50		WSW	1	Fair.
	2	0	43,5	43,5	29,59		SW	1	Fine.
13	8	0	35,0	41,0	29,73		WSW	1	Fair.
	2	0	45,0	43,0	29,83		NE	1	Cloudy.
14	8	0	39,5	41,5	29,78		E by N	1	Foggy.
	2	0	45,0	43,0	29,71		NE	1	Cloudy and rain.
15	8	0	51,0	47,0	29,43	0,264	SSE	1	Rainy.
	2	0	55,0	48,0	29,48		SW	1	Cloudy and rainy.
16	8	0	47,0	49,0	29,58	0,149	S by W	1	Fair.
	2	0	54,5	51,0	29,64		SW	1	Rainy.

METE-

METEOROLOGICAL JOURNAL
for November 1778.

	Time.		Therm. without	Therm. within.	Barom.	Rain.	Winds.		Weather.
	H.	M.			Inches.	Inch.	Points.	Str.	
Nov. 17	8	0	49,5	50,5	29,59	0,249	SSW	1	Fair.
	2	0	52,0	51,5	29,58		SW	1	Fair.
18	8	0	44,0	49,5	29,61		WSW	1	Fair.
	2	0	47,0	48,0	29,66		SW	1	Fine.
19	8	0	45,5	47,5	29,87		N by W	1	Fair.
	2	0	47,0	47,5	29,99		NW	1	Cloudy.
20	8	0	45,5	48,0	29,97		SE by E	1	Cloudy.
	2	0	48,0	48,5	29,90		SE	1	Rainy.
21	8	0	46,0	47,5	30,00	0,234	S by W	1	Cloudy.
	2	0	50,0	49,0	30,01		SW	1	Rainy.
22	8	0	49,5	49,0	29,93		SW	1	Cloudy.
	2	0	51,0	52,0	29,90		SW	1	Cloudy.
23	8	0	55,0	53,0	29,63	0,168	SW	2	Cloudy.
	2	0	57,0	52,5	29,64		SW	2	Cloudy.
24	8	0	56,5	56,0	29,53	0,263	SW	2	Fair.
	2	0	56,0	57,5	29,45		SW	3	Rainy.
25	8	0	45,0	53 0	29,73	0,261	SW	2	Fine.
	2	0	49,0	52,0	29,96		SW	2	Fine.
26	8	0	41,0	48,0	30,10		WSW	1	Fine.
	2	0	48,5	50,0	29,84		SW	1	Fine.
27	8	0	50,0	51,0	29,26	0,318	SW	3	Rain and windy.
	2	0	45,0	49,5	29,35		SW	1	Fair.
28	8	0	41,5	48,5	29,85	0,025	SW	1	Fair.
	2	0	50,0	50,0	29,95		SW	1	Fine.
29	8	0	43,5	47,0	29,98		SE by S	1	Fair.
	2	0	50,0	38,0	29,88		NE	1	Fine.
30	8	0	42,0	47,5	29,77	0,073	NW	1	Fair.
	2	0	49,0	50,0	29,86		NW	1	Fine.

METE-

METEOROLOGICAL JOURNAL
for December 1778.

	Time. H.	M.	Therm. without	Therm. within.	Barom. Inches.	Rain. Inch.	Winds. Points.	Str.	Weather.
Dec. 1	8	0	32,0	42,0	30,12		SW	1	Fair and frosty.
	2	0	40,0	41,0	30,02		SW	1	Fine.
2	8	0	36,0	40,0	29,54		SE	1	Fair.
	2	0	40,0	41,5	29,42		SW	1	Cloudy.
3	8	0	40,5	41,5	29,19	0,125	SE	1	Fair.
	2	0	45,0	46,0	29,16		SE	1	Cloudy.
4	8	0	43,0	44,5	28,55	0,495	SSE	2	Rain and much wind last n
	2	0	44,0	43,0	28,79		SE	2	Rainy.
5	8	0	37,0	43,0	29,00	0,038	S	1	Fair.
	2	0	42,0	43,5	28,91		NNE	1	Rainy.
6	8	0	35,0	40,5	29,19	0,130	SW	1	Fair.
	2	0	40,5	44,5	29,37		SW	1	Fine.
7	8	0	50,5	44,5	29,03	0,206	SW by S	2	Fair.
	2	0	47,0	46,0	29,32		SW	2	Fair.
8	8	0	50,5	46,5	29,40	0,130	SSW	3	Rain and much wind last n
	2	0	55,0	58,5	29,45		SSW	3	Rainy.
9	8	0	48,5	50,5	29,79	0,187	SW	1	Fair.
	2	0	56,0	53,0	29,88		SW	1	Fair.
10	8	0	49,5	52,0	29,67	0,114	S by W	1	Cloudy.
	2	0	52,0	53,0	29,64		SW	1	Cloudy.
11	8	0	51,5	52,0	29,63	0,135	SW	2	Cloudy.
	2	0	54,5	53,5	29,58		SW	2	Cloudy.
12	8	0	53,0	54,0	29,48	0,036	SW by S	2	Cloudy.
	2	0	53,0	54,5	29,38		SW	2	Fine.
13	8	0	47,5	52,5	29,13	0,051	SW	1	Fair.
	2	0	48,0	52,5	29,21		SW	1	Rain.
14	8	0	42,0	48,5	29,44	0,350	SW by S	1	Fair.
	2	0	48,0	50,0	29,39		SE	1	Rainy and cloudy.
15	8	0	41,0	46,0	29,66	0,096	W by S	2	Fair.
	2	0	44,0	46,5	29,88		SW	1	Fine.
16	8	0	34,5	41,0	30,15		SW	1	Fair.
	2	0	42,0	43,0	30,21		SW	1	Cloudy.

METEOROLOGICAL JOURNAL

for December 1778.

	Time.	Therm. without	Therm within.	Barom.	Rain.	Winds.		Weather.
	H. M.			Inches	Inch.	Points.	Str.	
Dec. 17	8 0	43,0	43,5	30,25		WSW	1	Cloudy.
	2 0	47,5	44,5	30,33		SW	1	Fine.
18	8 0	48,0	47,0	30,33		SW	1	Cloudy.
	2 0	52,0	50,0	30,36		SW	1	Cloudy.
19	8 0	49,5	51,0	30,19		SW	2	Cloudy.
	2 0	52,5	51,5	30,17		SW	1	Cloudy.
20	8 0	38,5	47,0	30,34	0,051	W by S	1	Fair.
	2 0	45,0	47,0	30,32		SW	1	Fine.
21	8 0	45,0	47,0	30,37		SW	1	Foggy.
	2 0	47,0	49,0	30,44		W	1	Foggy and cloudy.
22	8 0	44,5	47,5	30,38		WSW	1	Cloudy.
	2 0	45,0	48,5	30,35		WSW	1	Cloudy.
23	8 0	43,5	48,0	30 31	0,010	WSW	1	Rainy.
	2 0	45,0	50,0	30,36		NW	1	Cloudy and rain.
24	8 0	44,5	47,5	30,54	0,032	N by E	1	Cloudy and rainy.
	2 0	48,0	48,0	30,64		NE	1	Cloudy and rainy.
25	8 0	44,5	48,5	30,71	0,033	ESE	1	Foggy.
	2 0	46,0	49,0	30,75		ESE	1	Foggy and Cloudy.
26	8 0	34,5	44,5	30,77		SSW	1	Clear.
	2 0	40,0	45,0	30,81		SSW	1	Clear and fine.
27	8 0	33,0	40,0	30,73		SSW	1	Foggy.
	2 0	38,5	41,0	30,64		SSE	1	Cloudy.
28	8 0	39,0	41,5	30,16		SW	1	Fair.
	2 0	45,0	44,5	30,09		SW	1	Cloudy.
29	8 0	44,0	43,0	29,76	0,060	WSW	2	Rain and much wind last n.
	2 0	50,0	47,5	29,58		NW	2	Rain and cloudy.
30	8 0	35,5	42,0	29,89	0,040	W	1	Cloudy.
	2 0	42,0	43,0	29,87		SW	1	Fine.
31	8 0	48,5	45,5	29,60	0,125	W by S	2	Cloudy.
	2 0	50,0	46,5	29.18		SW	3	Cloudy.

1778.	Thermometer, without.			Thermometer, within.			Barometer.			Rain.
	Greateſt Height.	Leaſt Height.	Mean Height.	Greateſt Height.	Leaſt Height.	Mean Height.	Greateſt Height.	Leaſt Height.	Mean Height.	Inches.
January	48,0	22,0	37,1	48,5	30,0	38,9	30,22	28,59	29,88	2,111
February	49,0	25,5	38,2	48,0	32,5	39,6	30,35	29,15	29,82	0,527
March	60,0	31,5	42,3	58,0	35,0	43,4	30,43	29,02	29,78	1,243
April	71,5	34,5	50,0	63,0	42,0	51,3	30,24	29,30	29,76	0,734
May	71,5	49,0	58,5	65,0	52,0	58,4	30,28	29,34	29,89	1,133
June	82,0	51,0	65,0	78,0	55,0	66,3	30,36	29,64	30,05	0,957
July	86,0	58,5	70,3	81,0	63,0	71,0	30,29	29,48	29,98	3,053
Auguſt	82,0	47,0	67,0	76,5	57,5	68,0	30,51	29,59	30,31	1,039
September	71,0	36,5	56,1	67,5	47,0	58,4	30,42	29,15	29,77	0,735
October	64,5	31,5	48,3	68,5	40,0	50,3	30,16	29,17	29,63	2,903
November	57,0	32,5	47,0	57,5	38,0	45,1	30,27	28,95	29,68	3,897
December	56,0	32,0	44,7	58,5	40,0	46,7	30,81	28,55	29,85	2,440
Whole Year			52,0			53,1			29,86	20,772

I VARIA-

VARIATION NEEDLE.

	7 h. A.M.	12 h. M.	2 h. P.M.	10 or 11 h. P.M.	Daily Means.
	° ′	° ′	° ′	° ′	° ′
June 29	— —	— —	— —	22 22	22 23
30	22 7	22 22	22 25	22 18	22 18
July 1	22 7	22 28	22 27	22 13	22 19
2	22 3	22 24	22 30	22 7	22 13
3	22 7	22 27	22 30	22 18	22 20
4	22 10	22 24	22 33	22 14	22 18
5	22 8	22 25	22 27	22 24	22 21
6	22 12	22 26	22 28	22 21	22 22
7	22 9	22 29	22 43	22 14	22 24
8	22 18	22 19	22 25	22 20	22 21
9	22 10	22 26	22 28	22 28	22 23
10	22 9	22 27	22 28	22 27	22 23
11	22 9	22 26	22 24	22 21	22 20
12	22 8	22 28	22 36	22 2	22 18
13	22 10	22 30	22 30	— —	22 17
Means	22 9	22 26	22 28	22 18	

Mean of all 22° 20′¼.

It was found by the method deſcribed in Phil. Tranſ. vol. LXVI. p. 387. that the variation ſhewn by the in-

ſtrument is $9\frac{1}{4}'$ too great, ſo that the mean variation is really only 22° 11′; and, therefore, as the variation at the Society's Houſe ſeems to be $15\frac{1}{4}'$ greater than it ought to be, by reaſon of the magnetiſm of the building (*vide* the ſame place) the true variation ſeems to be 21° $55\frac{1}{4}'$.

The reaſon why the inſtrument now ſhews the variation $9\frac{1}{4}'$ too great, whereas before the errors was inſenſibls is, that a ſmall alteration has been made in the agate cap of the needle ſince the laſt year's obſervations, as it was thought not to have been faſtened before in a ſufficiently ſteady manner.

DIPPING NEEDLE.

	7 h. A.M.	12 h. M.	2 h. P.M.	10 or 11 P.M.	Mean.	
	° ′	° ′	° ′	° ′	° ′	
June 29	– –	– –	– –	73 35		
30	73 20	73 20	73 15	73 10	73 16	West mark down.
July 1	73 15	73 20	73 10	73 10		
2	73 15	73 15	73 10	73 20		
3	73 10	71 50	71 45	71 50		
4	71 50	71 50	71 50	71 50	71 47	East.
5	71 50	71 45	71 45	71 40		
6	71 50	71 40	71 40	71 25		
7	71 20	71 25	71 10	71 20	71 25	West mark uppermoſt.
8	71 25	71 25	71 25	71 30		
9	71 25	71 50	71 25	71 30		
10	71 15	73 15	73 10	73 10		
11	73 20	73 30	73 10	73 40	73 16	East
12	73 10	73 10	73 0	73 10		
13	73 20	73 15	73 25	– –		

THE END OF VOL. LXIX. PART I.

ERRATA.

VOL. LXVIII. PART II.

Page. Line.

789. 12. *for* ARTEDE *read* ARTEDI

VOL. LXIX. PART I.

13. 19. *for* was *read* were

15. 5. for *aricæ forme* read *aricæ-forme*

18. 7. for *erica*, formed, *read erica*-formed

21. 13. *for* produces *read* produce

32. 8. *for* it *read* its

79. 15. *for* ſuppoſita *pro* ſuppoſito

118. 7. *for* at the ſea *read* at ſea

123. 1. *for* ⊙ *read* ○

132. 3. *for* obſervation *read* obſervations

149. 8. *for* kind *mentus* read kind of *mentus*